FOOD AND ITS FUNCTIONS

KNIGHT

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A TEXT-BOOK
FOR STUDENTS OF COOKERY

BY

JAMES KNIGHT
M.A., D.Sc., F.C.S., F.G.S.
Lecturer in Physiology and Hygiene, High School of Glasgow;
Lecturer in Dietetics to the Glasgow School of Cookery and the West End School of Cookery.

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PREFACE.

Although the preparation of food is one of the oldest of the arts, Cookery as an applied science is still in its infancy, and only within recent years have any serious attempts been made to place diet and dietetics upon a proper scientific foundation. Based as it is upon physiology and chemistry, it is impossible to secure the rational treatment of food without at least a slight acquaintance with food-stuffs in general, with the chemical and other changes induced by cooking, and above all, with the subsequent course of the food within the body itself. In spite of the activity of the Science and Art Department and kindred bodies, it is to be feared that popular instruction in the sciences in question has reached only one sex, and that the one less concerned with food preparation, and of the majority of us it may still be said without slander that we are concerned not so much with the history of the last meal as with the prospects of the next. More liberal views of education, however, are now prevailing, and no teacher of cookery can secure a first-class diploma without some knowledge of the chemistry of foods and the digestive processes, while the code for evening continuation schools liberally encourages the popular teaching of such subjects.

The present volume is an expansion of the course of lectures on dietetics which the author has been privileged to deliver to the students in training at the Glasgow Schools of Cookery, and it aims at supplying such

students with a complete manual of the theoretical part of their curriculum. While specially written for these, the lessons have been carefully graded and illustrated by examples drawn from household practice, so as to lead the most general reader by easy stages to a vantage-ground from which he may peer into the regions beyond, still unexplored, where life comes out of death, where dead matter passes into living tissue, and though on this point his curiosity may be excited only, not satisfied, still the intelligent reader will at least learn something of the mystery of eating and drinking, and treat his body with the respect due to a part, the lowest part it is true, but still a part of that trinity in miniature called man.

While drawing largely upon the works of such standard writers as Parkes, Pavy, Williams, and Sir Henry Thompson, the author desires to acknowledge his indebtedness to the physiological works of Landois and Stirling and Professor M'Kendrick, and more especially to Burney Yeo's work on Foods.

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FOOD AND ITS FUNCTIONS.

Part I.—CHEMICAL PRELIMINARIES.

Lesson 1.—CARBON.

If a slice of bread be examined, two structures become apparent—the crust and the crumb. The latter, constituting the mass of the loaf, is white, porous, and comparatively tasteless, except for the salt and sugar added by the baker. It is easily softened by water, but yields very little to the water except the two substances already named. The crust, on the other hand, is dark-brown or even black, gummy-looking on the top, having a characteristic bitterish taste suggesting treacle, and fairly soluble in water, yielding a brownish solution. On toasting this slice before the fire, the following changes are observed:—

First steam rises, showing that bread contains a certain amount of **water**, mixed with it in the process of baking, and therefore easily driven off by heat. When the steam has all disappeared the crumb begins to get yellowish, then brown to almost black, and if the process be stopped at this stage and the apparently burned toast soaked in water, or floated on the surface, the water will become brown, showing that out of the white crumb there has been produced a new substance soluble in water, of a brown colour and tasting very like the original crust. What this substance is will be seen later on. Now let the toasting be continued till the bread becomes a mass of charcoal; when this occurs the bread has been carbonized, or turned into **Carbon**, which will by and by go on fire. As it burns there come off invisible vapours, which may be caught by holding over it an inverted tumbler, and a dimness produced in the tumbler shows that one of these vapours is *water*.

This is not the water used to make the bread, for all that has been expelled in the toasting; it is chemically-formed water,

the product of combustion of an invisible gas called **Hydrogen**, meaning "water-former". When the tumbler is covered and shaken up with a little lime-water inside, the latter is turned milky, revealing the presence of another product of combustion, a second gas, also invisible, but readily detected in this way; its name is **Carbonic Acid Gas**. Now let the whole of the bread be burned away on an iron plate, or, better, a piece of platinum foil, and there will be left a very small quantity of **ash**, about 2 per cent of the whole; this represents the mineral matter, not in the state in which it was originally present in the bread, but burned and altered in the process.

Bread, then, is a mixture of flour and water; but the former is not a simple substance, but a **compound**, containing, among other things, carbon and hydrogen. Further than these we cannot get, since they are both **elements**, that is, they cannot be decomposed into still simpler substances. In toasting this bread we have also arrived at a simple method of chemical analysis, applicable to most foods, namely, the detection of carbon as carbonic acid gas by lime-water, and the detection of hydrogen as water.

The experiment may be varied by heating some sugar in a porcelain basin. The sugar melts, becomes darker in colour, and gives off vapours, some of which smell of burnt sugar or caramel, while others are inflammable; and there is left behind a mass of charcoal or carbon which is precisely like the carbon obtained from bread, except that it leaves no ash to speak of. Sugar is, therefore, another compound containing carbon and hydrogen. The existence of these elements in sugar may be proved with less trouble by pouring upon the sugar a little strong oil of vitriol or sulphuric acid. The sugar darkens and swells up, evolving steam and caramel-smelling vapours, and leaves a porous mass of charcoal as before.

By means of sulphuric acid the presence of carbon especially may be revealed in many bodies; in all food-stuffs, in wood, paper, even in the human skin, for it also is charred by the strong acid. There is, however, another means of detecting the presence of carbon, and at the same time of estimating its amount. When a glass is inverted over burning charcoal, so as to capture the invisible products of combustion, there is among them carbonic acid gas, which turns lime-water milky. Carbon is the only *element* which on burning in air yields this gas, hence any substance which in burning produces carbonic acid gas, as shown by the lime-water test, must have

contained carbon. This method may be applied to various substances, such as a taper or candle, oils and fats of various kinds, coal-gas, a splinter of wood, or a bit of meat, and in each case there will be the same result—the formation of carbonic acid gas and water, proving that all these substances are compounds, containing at least two elements, one of them carbon, the other hydrogen.

Now if we breathe into a cold dry tumbler, a dimness forms on the glass, as in the case of the burning candle, and if the tumbler be shaken up with lime-water a milkiness appears as before. It would thus seem that breath contains products of combustion, a combustion going on within the body, for ordinary air behaves quite differently. This suspicion turns out to be well founded; although there is neither smoke nor flame there is heat, **animal heat**, and in this light the body may be regarded as a furnace with the mouth for one of its chimneys. But a furnace requires fuel, and the human furnace receives its fuel in the shape of food, and indeed the chief reason why food is taken at all is not so much to repair bodily waste as to maintain animal heat, four-fifths of the food being devoted to this object. The body, in short, is an engine, and like other engines produces heat and work, but it differs from all other engines in this important respect—that it is continuously self-repairing as well as self-adjusting, and obtains material for repairs from the fuel itself.

What we have learned:—

1. All food-stuffs contain water.
2. They all contain carbon and hydrogen.
3. When burned in air they form carbonic acid gas and water, and liberate heat.
4. The breath contains these same products of combustion.
5. The body is thus a heat-producing apparatus.
6. The body-fuel is food.
7. Cooking often effects chemical changes upon food.

Lesson 2.—OXYGEN AND COMBUSTION.

Combustion.—The human body may thus be regarded as an engine, the furnace of which is supplied with food by way of fuel. To understand more clearly what is meant by

combustion, it will be well to repeat a classical experiment. Take a lighted candle and cover it with a large glass jar over water, so that no air gets in. The glass becomes dim, owing to the formation of water out of the hydrogen in the wax; then the candle burns feebly, smokes, goes out. The lime-water test applied to the contents of the jar will show that carbonic acid gas has been formed, and a lighted taper thrust into the jar is extinguished. Since this does not occur in ordinary air, it is clear that the composition of the air has somehow been altered by the burning of the candle. This may be better tested by employing phosphorus, a substance which burns more vigorously than a candle, and which has the further advantage of producing a white solid substance instead of invisible fumes. When phosphorus is burned over water under a stoppered bell-jar, the combustion is rapid and brilliant; dense white fumes fill the jar, and the latter becomes warm, a witness of the amount of heat evolved. In a few minutes, however, the fumes settle down and dissolve in the water, leaving the jar apparently empty, and the water has risen inside the jar to the extent of one-fifth, showing that one-fifth of the air has somehow been removed. If now a lighted taper be inserted, it is extinguished, as in the case of the candle, but the lime-water test gives no result. Add to the water in the bell-jar a few drops of blue-litmus solution: it reddens. Taste a little of the water: it is pretty sour. Substances which redden blue litmus and have a sour taste are called **Acids**, and this particular acid is *phosphoric acid*, and it forms a set of compounds called *phosphates*. The air then consists chiefly of two gases, one of which supports combustion, while the other, the gas left in the jar, does not. This latter gas, which forms four-fifths of the bulk of air, has neither colour, taste, nor smell, will neither support combustion nor burn itself, and it is called **Nitrogen**. The gas which has been used up in burning the phosphorus forms one-fifth of the air, is also without colour, taste, or smell, and it is called **Oxygen**. It is with the oxygen of the air that we have chiefly to deal, for the nitrogen seems to be useful chiefly in diluting the oxygen.

Fig. 1.—Preparation of Nitrogen.

In order to examine this gas, which is of prime importance in the human economy, it will be better to prepare two gallons or so. The gas is readily supplied for lime-light purposes in steel cylinders, but if these should not be available a supply can easily be got by heating in a flask a table-spoonful ot potassium chlorate mixed with about one-third of its weight of manganese dioxide. The flask is fitted with a delivery-tube which dips under water, as shown in the figure, and the gas may be collected in jars filled with water and inverted in a basin of water. This arrangement is called a "pneumatic trough", and may always be used for collecting gases which are nearly insoluble in water. When each jar is filled, it may

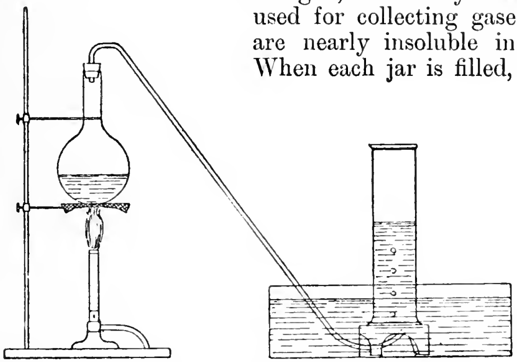


Fig. 2.—Preparation of Oxygen.

be covered with a glass plate and set aside; a little grease on the edge of the jar will prevent any escape of gas. A jar of oxygen, thus obtained, is to all appearance empty, since oxygen is colourless. If now a piece of charcoal is heated to redness, and while still glowing plunged into the gas, it breaks into brilliant combustion, and the jar becomes slightly warm, for heat is evolved in every case of direct chemical union. When the combustion is over, replace the cover, add lime-water and litmus solution, and shake up; the lime-water becomes milky from carbonic acid gas, and the litmus changes from blue to purplish-red, thus giving an explanation of the name carbonic *acid* gas. This experiment can be utilized as a test for oxygen, which reveals its presence by rekindling a glowing splinter of wood.

If now a little lime-water be placed in a saucer and set aside for an hour or so, it will get faintly milky, showing that there

is in air a small quantity of carbonic acid gas, about 4 parts in 10,000. Since this gas is formed in the breath and by the combustion of coal, candles, coal-gas, &c., the proportion will be much greater in occupied and badly-ventilated rooms, and may rise to as much as 10 per 10,000.

In a second jar of oxygen burn some sulphur in a spoon. The sulphur, which in ordinary air burns with a feeble blue flame, burns with greatly increased vigour, forming a suffocating gas, accompanied by thin white fumes. On shaking up with litmus the solution becomes intensely red, showing that another acid has been formed by the union of sulphur and oxygen. It was at first supposed that oxygen behaved in this way with all elements, and so it got its name, "Oxygen", meaning acid-former. Some substances, such as carbon, sulphur, and phosphorus do form acids, but other substances give rise to products of quite a different nature. Whether acid or not, the products obtained when an element combines with oxygen, whether by burning or in any other way, are called **Oxides**, and the element is said to be *oxidized.* Thus there is carbon oxide, sulphur oxide, phosphorus oxide, and so on; but it so happens that these very elements can combine with oxygen in more than one proportion; thus, sulphur can use up either its own weight of oxygen or half as much again, forming sulphur dioxide and trioxide respectively. Carbon, again, burned in air or oxygen, combines with the latter in the proportions of 12 of carbon to 32 of oxygen, forming carbonic acid gas; but as there is another oxide of carbon containing only half that amount of oxygen, carbonic acid gas, which is more fully oxidized, is called carbon dioxide.

A great many interesting experiments might be made with oxygen to demonstrate the properties of different oxides. Iron wire, which will not burn at all in air, burns like a pyrotechnic display in oxygen, forming a black oxide of iron, while zinc forms white oxide of zinc, and so on. The same process takes place in air, though more slowly, and often with the formation of a different oxide. Thus iron rusts in air, forming a brown oxide of iron, and many metals become tarnished with a film of oxide. In these cases the combustion is slow, as in the human body; heat is produced, and to the same extent, but it is unaccompanied by smoke or flame, its production is spread over weeks instead of minutes, and hence its amount passes unnoticed. The following experiment is of some value in connection with dietetics. If ordinary dark blood be shaken

up with oxygen it becomes bright scarlet, showing that the crimson colouring matter of the blood has taken up oxygen, or has been oxidized, forming a scarlet compound. This very oxidation takes place within the body, and accounts for the bright scarlet appearance of arterial as opposed to venous blood.

Since oxygen is continually being removed from the air by the action of animals and fires, there might arise the question, "Why does not the oxygen become exhausted?" Since the nitrogen of the air is a purely passive gas, such a contingency would have the dire consequence of extinguishing both lights and life. To solve the mystery, one has only to watch the green leaves of some water-plant, or a leaf of mint in a tumbler full of water. In presence of sunlight little bubbles of gas are seen to form on the surface of the leaf, and by and by they are disengaged and rise to the surface. When the gas thus produced is tested by a glowing match it is found to be oxygen, so that green plants are all day long manufacturing oxygen gas, and in this respect their action is precisely the reverse of our own; we consume oxygen and give out carbonic acid gas, they take this waste product and decompose it, keeping the carbon and liberating the oxygen. Thus animal life is an **oxidizing** process; plant life is generally a **reducing** process, since the carbonic acid gas is deprived of some of its oxygen. Plants and animals thus keep up a continuous cycle of atmospheric regeneration, and every blade of grass in our city parks is contributing its quota to the supply of that somewhat costly commodity, fresh air. The following table, adapted from Faraday, will convey some idea of the important part which oxygen plays in this world:—

In Animal matters	Principles	$\frac{1}{4}$	average $\frac{3}{4}$.
	Phosphate of Lime	$\frac{3}{7}$	
	Water	$\frac{8}{9}$	
,, Vegetable matters	Principles	$\frac{1}{3}$	,, $\frac{4}{5}$.
	Water	$\frac{8}{9}$	
,, Mineral matters	Silica	$\frac{1}{2}$	,, $\frac{1}{2}$.
	Alumina	$\frac{1}{3}$	
	Lime	$\frac{1}{4}$	
,, Ocean and waters		$\frac{8}{9}$.	
,, Atmosphere		$\frac{1}{5}$.	

Oxygen thus constitutes from $\frac{2}{3}$ to $\frac{3}{4}$ of the entire globe, being by far the most abundant element.

What we have learned:—

1. Air is necessary for combustion.
2. It consists of nitrogen ($\frac{4}{5}$) and oxygen ($\frac{1}{5}$), with a trace of carbonic acid gas.
3. The oxygen is the active constituent of the air.
4. Elements combining with oxygen form *oxides.*
5. Some of these oxides are *acids.*
6. Acids may be recognized by their sour taste, and by reddening blue litmus.
7. Heat is evolved in chemical action.
8. Animals are *oxidizing* agents, forming carbonic acid, water, &c.
9. Plants are *reducing* agents, liberating oxygen.

Lesson 3.—HYDROGEN.

In the previous lessons it has been seen that when bread, wax, wood, &c., burn in air there is generally water formed, and that water is therefore the oxide of some substance or other. To discover this substance and examine it more fully an experiment or two will be required, and this time the method of reduction will be employed. When steam is passed through a red-hot gun-barrel filled with iron-turnings and connected by a delivery-tube to a pneumatic trough, there is obtained a gas which, like oxygen and nitrogen, has neither colour, taste, nor smell. It differs from oxygen, however, in its behaviour with respect to a lighted taper; the taper goes out when inserted into a jar of the gas, but the latter burns with a pale-blue, almost invisible and very hot flame. Further, when the glass jar is observed it will be seen to be quite dim, showing that water is formed, and that the gas in question is **hydrogen**, an element found in all foods and whose oxide is water. In that experiment the iron acted as a reducing agent, depriving the water of oxygen so as to form iron oxide, and liberating hydrogen gas. The production of water in this way may be utilized as a means of estimating the amount of hydrogen in a substance, for of the water hydrogen forms $\frac{1}{9}$ by weight, the other $\frac{8}{9}$ being oxygen. There are several metals besides iron capable of decomposing water; two of them, sodium and potassium, do so without the aid of heat, and form the important substances soda and potash respectively. Water may also be decomposed by passing through it a strong electric

current, and the two gases of which it is composed may by suitable means be collected separately, when it will be found, as already stated, that water consists of hydrogen and oxygen in the proportion by weight of one to eight. If the separate gases be mixed nothing occurs, but if the mixed gases be kindled a violent explosion takes place, great heat is evolved, showing how intense is this chemical action, and there is produced steam and nothing else. The heat generated by the combustion of hydrogen is fully four times as much as that from the burning of carbon, and, next to the electric arc, the oxy-hydrogen blow-pipe furnishes the most intense heat available.

It is sometimes useful to know how much heat can be got from a fuel or a food-stuff. It is well known that the quality of our diet varies with the season of the year, and that certain foods, such as fats, are specially marked off as "heat-givers". A little reflection will show that all foods are heat-givers, inasmuch as they all contain combustible material, carbon and hydrogen. One must, however, distinguish between **amount of heat** and *degree* or intensity of heat. A tea-cup and a quart jug filled from the same kettle of hot water will show the same intensity of heat, as tested by a thermometer; but the amount of heat in the jug would be about eight times that in the tea-cup. Intensity of heat is measured by the thermometer, amount of heat by the calorimeter. Intensity of heat is reckoned in *degrees*, the freezing-point of water being taken as zero, or in Fahrenheit's scale 32°, and the boiling-point 100° (212° F.). Amount of heat is reckoned in *calories*, a calorie being the amount of heat required to raise 1 gram of water—about $15\frac{1}{2}$ grains—1° Centigrade. Measured in this way the heat evolved by the combustion of 1 grain of hydrogen amounts to 34,460 calories, and that from 1 gram of carbon to 8040 calories. The following is a statement of the results obtained by burning various food-stuffs in a calorimeter, although one must not assume that these figures represent exactly the relative value of food-stuffs as heat-producers when consumed within the body. For heat-giving purposes it is thus seen that 100 parts of animal albumen = 52 fat = 114 starch = 129 dextrose, while 100 parts of vegetable albumen = 55 fat = 121 starch = 137 dextrose; but the fact is notorious that vegetable albumen is not so readily digested and assimilated as animal albumen, so that calorimetric figures are valuable only within certain limits.

The production of heat from the slow combustion of food within the body is a good example of the **transformation of energy**. Everybody knows George Stephenson's statement that his train was driven, not so much by a canny Newcastle driver, as by the heat and light of the sun. Plants store up this solar energy in the form of chemical energy, and when this is liberated part of it always takes the form of heat; indeed, in a person resting it may be said that all the chemical energy of the food and air appears internally as heat. Just as Stephenson utilized the sunlight "bottled" in coal to drive his engine, so we utilize the sunlight bottled in vegetables—and we are all vegetarians in the end—to produce mechanical work. Chemical energy, however, cannot be transformed into mechanical work without heat being produced at the same time, and an engineer designs and works his engine so as to get the maximum of work and the minimum of heat. After all his pains the very best steam-engine gives out in the form of work only $\frac{1}{8}$ of the chemical energy of the fuel, the remaining $\frac{7}{8}$ being dissipated as heat; while the body, as already mentioned, produces $\frac{1}{5}$ as work and $\frac{4}{5}$ as heat. Thus, fuel for fuel, the body generates nearly twice as much as the best steam-engine, and the calorimetrical results quoted above may be taken as indicating the relative values of foods, not merely as heat-givers but as work-producers. Looking to the high position which fat occupies on the list, and 100 parts of fat $= 243$ of dry flesh, it will readily appear that the late Emperor William was on sound physiological ground when he added to the daily rations of his soldiers in the Franco-German war half a pound of fat bacon per head. Speaking in modern scientific language, the body may be described as an instrument transforming the stored-up **potential energy** of plants and other food materials into **kinetic energy** as seen in heat and mechanical work.

What we have learned:—

1. When hydrogen is oxidized water is formed.
2. In all direct chemical union heat is evolved.
3. The intensity of heat is measured in degrees by a thermometer.
4. The amount of heat is measured in calories by a calorimeter.
5. The fuel-value of a food-stuff depends on the quantity of unconsumed carbon or hydrogen in it.
6. All foods contain at least one of these in available form, so that all foods are heat-givers.

7. The potential energy of the food appears as heat and mechanical work, four-fifths and one-fifth respectively.

Lesson 4.—NITROGEN AND ITS COMPOUNDS. ACIDS, ALKALIES, AND SALTS.

In the second lesson it was shown that air is composed chiefly of two gases, oxygen and nitrogen, in the proportion of one to four. An easy method of obtaining nitrogen from the air is there described, and it consists simply in removing the oxygen by some easily oxidizable substance, such as phosphorus. As thus obtained, nitrogen is a colourless, odourless gas, neither burning itself nor supporting combustion, apparently without any active properties. Although this element is so passive chemically, physiologically it is of prime importance, since it is inseparably associated with *life*. Both in plants and animals every active tissue contains nitrogen. It is present in large quantity in the muscles and the brain, in the digestive juices and other secretions; even such passive structures as the bones are nitrogenous, especially at the seat of growth. If nitrogen be withheld from the body the latter dies, although for a while the more indispensable organs draw upon the nitrogen in the system, thus producing a kind of tissue-consumption. Again, when extra work has to be done, the quantity of nitrogenous food taken must be increased in proportion, and that to a greater extent than with the other classes of food-stuffs. This necessary element must be supplied wholly in the form of nitrogenous food, for although the air inspired contains four-fifths of its bulk of nitrogen, the whole of this is returned unused, it being only the oxygen that is utilized in the lungs.

Within the last year there has been obtained from atmospheric nitrogen a new element, also a gas, called **Argon**, but this forms only three-fourths per cent of the total air, and as its properties, chemical and physiological, are only now being investigated, it may be neglected for the present.

Although nitrogen itself possesses slight chemical activity, there are two of its compounds which deserve special mention on account of their intensity of action, namely, **Ammonia** and **Nitric Acid**. The former is always obtained as a gas when any nitrogenous substance is heated in a closed air-space.

Thus, if coal-dust be heated in a test-tube, coal-gas is formed on a small scale, tarry vapours are given off, and also ammonia, which may be recognized by its pungent smell. A tuft of hair or a bunch of feathers when burnt will give similar results, hence burnt feathers are popularly used as a stimulant in cases of fainting. The gardener utilizes this property of decaying organic matter in the preparation of hot-beds from dung and vegetable débris. Smelling-salts, or sal-volatile, consist of carbonate of ammonia, and part with their ammonia very freely. If a nitrogenous substance be warmed with quicklime or caustic soda, ammonia gas comes off very readily, and in this way the presence of nitrogen may be demonstrated in meat, cheese, and other animal foods. This gas is formed during the decomposition of animal matter, and represents the final product of nitrogenous waste, but in the body that waste is removed in the form of **urea**, a solid substance rather more complex than ammonia. Outside the body urea decomposes, forming ammonia, carbon dioxide, and water.

The properties of the gas may be examined in the ordinary solution. If some litmus be reddened by the addition of an acid, and a little ammonia be added, the blue colour is restored. On adding more acid the litmus is again reddened, showing that ammonia and acids counteract each other. The solution has a soapy feel and taste, whereas acids are sour. Substances of this kind are called **Alkalies**, and ammonia ranks with potash, soda, and lime as one of the most powerful alkalies. Any alkali will neutralize an acid if added in sufficient quantity, so that alkalies are administered in cases of acid poisoning, and vice versa. If now some sulphuric acid be taken with a drop or two of litmus as an indicator, and ammonia solution be added cautiously, a point will be reached at which the litmus is neither red nor blue, but purple. This indicates that the acid has been *neutralized*, and is now neither acid nor alkaline. To discover what it is, expel the water in it by heating gently, and there will be left a white crystalline mass, an entirely new substance, ammonium sulphate. When any acid is neutralized by an alkali, heat is liberated, as in all direct chemical action, and there is formed a **salt**, generally a solid substance, and not necessarily salt to taste.

The other important nitrogen compound is **nitric acid**, or aqua fortis. It shows all the properties of an acid, and when neutralized by any alkali forms a set of salts called nitrates. It does not play a very important part in the chemistry of

food. Nitric acid stains on cloth are not restored by ammonia as was the case with other acids.

Now add some sulphuric acid to iron filings; the iron dissolves, there is given off a gas which turns out to be hydrogen and a greenish solution is left. On expelling water from this solution green crystals are obtained, consisting of another salt, this time iron sulphate. If copper turnings had been used instead of iron, and nitric instead of sulphuric acid, another salt, consisting of copper nitrate, would have been obtained. Now dip the blade of a knife into, say, copper-sulphate solution; after a minute or two the blade will be coated with copper. This is an example of the kind of chemical action known as **displacement**, and the experiment may be represented thus:—

$$\left.\begin{array}{c}\text{Copper + sulphuric acid}\\ \text{and iron}\end{array}\right\}\text{ form }\left\{\begin{array}{c}\text{iron + sulphuric acid}\\ \text{and copper.}\end{array}\right.$$

The iron and copper seem to have changed places, and a new salt has been formed, sulphate of iron, the iron having displaced the copper.

Now take some crystals of tartaric acid and add them to a solution of baking-soda. Effervescence follows, and the escaping gas is found by the lime-water test to be carbonic acid gas. Baking-soda is another salt, a carbonate of soda, and here again there is displacement, this time of one acid by another, thus:—

$$\left.\begin{array}{c}\text{Soda + carbonic acid}\\ \text{and tartaric acid}\end{array}\right\}\text{ form }\left\{\begin{array}{c}\text{soda + tartaric acid}\\ \text{and carbonic acid.}\end{array}\right.$$

In this case a tartrate of soda is formed, and in baking with the foregoing mixture this substance is left in the bread, while the carbonic acid gas in escaping inflates the bread and makes it porous. If hydrochloric acid be used instead of tartaric acid, a similar displacement would ensue, the new salt this time being sodium chloride or common salt. Lactic acid, which is the acid in butter-milk, would in like fashion form lactate of soda, acetic acid or vinegar would form acetate of soda, and so on. Carbonates, such as washing-soda or baking-soda, are easily decomposed by other acids, giving off carbonic acid gas, and it is in virtue of this property that they enter into the composition of so many baking-powders.

As another example of displacement, add some sulphuric acid to common salt. Dense white pungent fumes come off, which are the fumes of the hydrochloric acid displaced, and there is

left a mass of salt-cake, Glauber's salt or sodium sulphate. This action is important, since the active cells of the stomach glands manufacture hydrochloric acid, and of course the material is supplied to them in the form of the common salt and other chlorides eaten in food.

As an example of another kind of chemical action, take a solution of sugar of lead, a substance formed by acetic acid acting upon lead as a base, and therefore a salt, acetate of lead, and add to it a solution of Epsom salts or magnesium sulphate. A white substance is formed, insoluble in water, and it proves to be sulphate of lead, formed in this way:—

$$\left.\begin{array}{c}\text{Lead} + \text{acetic acid and}\\ \text{magnesium} + \text{sulphuric acid}\end{array}\right\} \text{form} \left\{\begin{array}{l}\text{lead} + \text{sulphuric acid and}\\ \text{magnesium} + \text{acetic acid.}\end{array}\right.$$

In this case both bases have changed acids, resulting in the formation of two new salts, sulphate of lead and acetate of magnesium; this kind of change is **double decomposition**.

Lastly, mix tartrate of potash and tartrate of soda, dissolve both in water and evaporate to dryness, and there are formed crystals of a tartrate of potash and soda, commonly called Rochelle salt, an example of a **double salt**, where two bases have combined with the same acid. The alums are familiar cases of this, common alum being the double sulphate of potash and alumina; so dolomite is a double carbonate, glass a double silicate, and so on.

If the proportion of acid be in excess of what is required for neutralization, an **acid salt** may be formed; thus baking-soda, or bicarbonate of sodium, is made by passing carbonic acid gas through a solution of the ordinary carbonate, washing-soda, thus:—

$$\left.\begin{array}{l}\text{Carbonate of soda}\\ \text{and carbonic acid}\end{array}\right\} \text{form } \textit{bi}\text{carbonate of soda.}$$

Another common acid salt is cream of tartar, or acid tartrate of potash. Similarly an excess of base might produce a **basic salt**. Changes of all these kinds occur in connection with the preparation and utilization of foods, and in every case heat is evolved.

SUMMARY.

1. Nitrogen is essential to life.
2. The body gets its nitrogen from food, not air.
3. Nitrogenous foods thus came to be called "flesh-forming".

4. The supply of nitrogen must keep pace with the output of energy.
5. Nitrogenous waste leaves the body chiefly as urea.
6. Alkalies are opposed to acids.
7. The chief alkalies are potash, soda, ammonia.
8. When an acid is neutralized by an alkali, a salt is formed.
9. Generally speaking, a salt = acid + base, the latter a metal or something equivalent.

PART II.—FOODS IN GENERAL.

LESSON 5.—CLASSIFICATION OF FOODS. PROTEIDS.

Having discovered that the body demands supplies of carbon, hydrogen, nitrogen, oxygen, &c., the next step is to determine in what way that demand is met. Our body is not a blast-furnace to be fed with charcoal, lime, and ironstone, even though these were supplied in the proportions necessary for life. Humiliating as it seems, we feed at second-hand. Plants alone can draw directly upon mother earth, storing up her treasures in the form of cellulose, starch, sugar, and the like; animals are all dependent upon the tissues already formed in plants, and even carnivorous animals do no more than draw their supplies of potential energy at third instead of at second-hand. Our stomachs are not adapted to the digestion of minerals, so that even when these are required, as in cases where the body is deficient in iron or lime, it is well to follow nature and supply the deficiency from vegetable sources.

Nature has provided two *perfect foods*, foods, that is to say, which contain the necessary nutriment in the proper proportions: these foods are eggs and milk. In saying that milk is a perfect food we must add, for an infant; it is not the most suitable food for an adult. Again, it must be borne in mind that the young chick, for whose use the food-materials of an egg are prepared, utilizes part of the shell as well as the yolk and the white, as may be seen by comparing the shell of a new-laid egg with that of one newly hatched.

Taking milk as a standard food, it is found to contain **fat**, which may be creamed off, and which constitutes the bulk of butter. If a little rennet or hydrochloric acid be added to

the skim-milk thus left, a solid curd is formed, which is the leading ingredient in cheese, and hence is called *casein.* It is a nitrogenous substance, in composition not unlike white of egg, and classed among albuminous or **proteid** foods. If the curd be removed, and the whey shaken up with alcohol, another white solid appears, which proves to be lactose or milk-sugar, one of the important class of substances known as **carbohydrates**. What is left is now apparently nothing but **water**, but on evaporating to dryness and igniting, a small quantity of **ash** is obtained. Milk thus consists of—

Nitrogenous:—	A proteid, viz. casein;
Non-nitrogenous:—	a fat—butter; a carbohydrate—lactose; various salts; and water.

Milk is thus not a simple substance, but a highly complex one, consisting of five **proximate principles**, viz. casein, fat, lactose, salts, and water. Each of these proximate principles may in turn be shown to be a chemical *compound*, and may by suitable means be resolved into its *elements*; but in so doing its value as a food-stuff is entirely destroyed, since it is only as proximate principles that the digestive organs can prepare and the tissues assimilate food.

As a type of **proteid** or albuminous food, we may take white of egg, which is almost pure albumen and water. On heating this, as in boiling or frying, the albumen is coagulated into a white opaque mass. This change is characteristic of nearly all proteids, and the great majority coagulate at about the same temperature—73° C. This property is utilized in the various processes of cooking meat. By subjecting a roast to a strong heat to begin with, the albuminous materials are coagulated on the surface, forming a continuous skin about the thickness of a sixpence; the temperature is then lowered, and the process completed by actually boiling the meat in its own juice. On the other hand, when the object is to extract from meat as much proteid matter as possible, as in making soups or beef-tea, the temperature of the water is kept just below the coagulating point of albumen—say, 66° to 75° C. (water boils at 100° C.).

A great many proteids are soluble in dilute solutions of salt, while others are rendered insoluble by the use of a strong salt solution such as brine. Thus the salt taken with meat not only supplies the blood with soda and the stomach with the

raw materials of hydrochloric acid, but aids in the solution of the meat. On the contrary, meat pickled by soaking in brine loses not merely water but a great part of its strength, since the albumens of muscle are dissolved out by the brine. In the case of milk, blood, and similar fluids, spontaneous coagulation of albuminous matter is effected by a ferment in presence of certain salts, notably those of lime, and the product is in the case of milk, *casein*, in blood, *fibrin*. Casein, it will be remembered, was produced by the action of rennet or a mineral acid upon milk, and when milk turns sour a similar change takes place; the sugar of milk or lactose is decomposed by the action of an aërial ferment and becomes lactic acid, which in turn coagulates a milk-albumen forming casein. Another milk-albumen may be got in the shape of the scum which forms when milk is heated; this is lact-albumen, and it coagulates at 77° C. The albumen of living muscle is *myosin*, but after death there sets in a peculiar change called *rigor mortis*, or death-stiffening, and as a consequence of this, lactic acid is formed, which again alters the myosin to *syntonin* or acid albumen. It is the last which is the chief proteid of meat.

All these are animal albuminates, but there are two well-known vegetable proteids which occur in foods. Every school-boy has manufactured "cracking-caoutchouc" or chewing-gum out of wheat grains or wheaten flour. This is a vegetable albumen called *gluten*, from its sticky nature, and it may be prepared in a more acceptable fashion thus. Fill a muslin bag with wheaten flour, and knead it under running water; the starch of the flour will all be washed away as a milky stream, while the gluten remains in the bag as a stringy, sticky, yellowish mass. The presence of gluten in wheat, oats, and other cereals is important, as gluten represents almost the sole nitrogenous proximate principle in these grains. The cells containing it lie just under the husk, and if the grain be over-ground, in the desire to obtain a fine white flour, most of the gluten may be removed, leaving nothing but starch. It is to the gluten that wheaten flour owes the adhesive properties utilized in baking. Oatmeal actually possesses more proteid matter than wheat, but its gluten is not in the same form, and has not the same adhesive properties on adding water, hence oats and barley are with difficulty made into bread.

Another vegetable albumen, found especially in pulse or pod-bearing plants, such as peas, beans, and lentils, is *legumin*, so called because these plants bear legumes or pods. These

seeds contain no less than from one-fifth to one-fourth of their own weight of nitrogenous matter, but owing to the absence of glutinous material cannot be baked into bread.

All these proteids are very complex bodies, containing the elements carbon, nitrogen, hydrogen, oxygen, and a little sulphur. Their composition varies, as shown in the following table:—

Carbon, ...	51·5 to 54·5	—average,	53·5 per cent.
Nitrogen, ...	15·2 „ 17·0	„	15·5 „
Hydrogen, ...	6·9 „ 7·3	„	7·0 „
Oxygen, ...	20·9 „ 23·5	„	22·4 „
Sulphur, ...	0·3 „ 2·0	„	1·6 „

The proportion of nitrogen to carbon in them is thus nearly 4 to 14, and they contain fully half their weight of carbon.

There is another class of nitrogenous substances closely allied to the albumens proper, and hence called albuminoids, or gelatinous substances, from their type, **Gelatin**. When any connective tissue, including bone and cartilage or gristle, is boiled for a long time, a solution is obtained which forms a jelly on cooling. From the several connective tissues various gelatins are obtained in this way. Thus from ordinary connective we get collagen, from bones ossein, from cartilage chondrin, from the superficial tissues, skin, nails, &c., keratin —all forms of gelatin. In composition they resemble the albumens; they contain less sulphur but more nitrogen, the proportions of nitrogen to carbon being 4 to 11. For purposes of nutrition they are inferior to albumen, although they admit of easy digestion, and so are often given in convalescence.

When a piece of meat is soaked in water, the latter dissolves out of the meat certain substances, called on that account **Extractives**. They are mostly nitrogenous substances, the chief being kreatin and kreatinin, and they play an important part in nutrition. Raw meat yields most extractives to water if finely minced and immersed in it for several hours at a very gentle heat, not exceeding the coagulating temperature of albumen—say, 73° C. This is the process of making "beef-tea", and when made with great care as much as 6 per cent of the nutritive material of the meat may be recovered. As usually made, however, beef-tea contains only from 1½ to 3 per cent, the heat employed being far too great, and inducing coagulation of the albuminous matters. The various extracts of meat are produced on the same principle; but it is a very

great mistake to suppose that they are foods at all, in the sense of supplying materials for the maintenance of the body. It is commonly supposed that in making beef-tea all the "strength" of the meat was obtained in the liquid, and that only a valueless mass of indigestible fibres was left behind. This is so far true that the hard fibres are indigestible by themselves, but if beef-tea or extract of meat be added, they become quite digestible, thus demonstrating the peculiar function of extractives, namely, to regulate the digestion and assimilation of proteids, more especially of the gelatins. Even pure albumen, in the form of white of egg, causes nausea after a while, and albumen appears in the urine, showing that it is not being properly assimilated, but behaving like a waste product. In no sense, however, are extractives foods; they act as stimulants, and from the ease with which they are decomposed save that tissue-consumption which has been already mentioned as characteristic of decline. They promote exchange of materials, and so quicken the "pace" of the vital activities. This effect was well demonstrated by a classical experiment made upon a litter of puppies. Some were fed on ordinary food, others on Liebig's extract, and the rest got no food at all. The first set got on all right, but the second lot died even earlier than those which were starved. In *Food and Sanitation*, 1893, the subject of meat extracts is thoroughly discussed from the analytical standpoint, and the following comparison of various extracts may be useful. The figures certainly justify the use of the term "Revelations" as the title of the articles. "Bovril" is the type of a meat extract which proceeds on sounder physiological principles, since it consists of the usual extract *plus* beef-powder or fibrin, obtained by carefully expelling all the water (about 75 per cent) from ordinary meat, and grinding the residue into powder. Subjoined is a detailed description of the whole process (*Commerce*, 1894):—

The beef is deprived of bone and superfluous fat, chopped very fine, and placed in enormous porcelain-lined vats containing cold water. This concoction passes through an elaborate series of straining and concentrating processes, *in vacuo* and otherwise, until the familiar preparation of extract of meat in the form of a paste is produced. This extract is essentially the soluble salts of flesh, which give to meat its flavour and odour. It is not a food; it does not go to form flesh in the human system; it is a nerve stimulant; it does not supply

ANALYSES OF MEAT EXTRACTS.

(*Food and Sanitation.*)

Name.	Water. Per cent.	Fat.	Gelatin and Albuminoids.	Peptones.	Kreatin and other Extractives.	Salt.	Other Mineral Matters.	Non-nitrogenous Extracttives.	Nutritive Value. Beef=100.
Liebig's Extract: 2 oz. cost 1*s.* 1½*d.*	16·87	3·04	1·35	8·20	47·32	5·08	17·46	0·68	·30
Valentine's Meat Juice: 2 oz. cost 3*s.*	55·24	4·80	0·93	1·55	18·27	2·62	8·51	8·08	2·8
Armour's Extract: 2 oz. cost 1*s.* 1½*d.*	15·55	2·63	2·16	8·73	43·23	7·62	18·29	1·49	
Brand's Essence: 3 oz. cost 1*s.* 2*d.*	91·23	0·18	1·25	2·54	3·96	0·45	0·39	0	
Mason's Essence: 2 oz. cost 11*d.*	77·07	1·34	2·56	0·47	7·47	6·64	2·87	1·58	
Bovinine: 2 oz. cost 11*d.*	80·70	1·21	12·92	0·62	0·21	0·78	0·08	3·48	72·40
Invalid Bovril: 2 oz. cost 11*d.*	16·46	2·72	23·87		31·94	19·48		5·53	
Coleman's Extract.	Total nitrogen ·087 to ·082 per cent. "Practically well-nigh devoid of extract of meat."								

vitality, but calls latent vitality into action. It is an old idea that beef-tea and extract of meat are in themselves nutritious, and this has led to death by starvation in thousands of cases. But modern research has rectified this erroneous impression, and all who have studied the subject are now aware that extract of meat can only be useful as a stimulant and a tonic, and as an adjunct to other more nutritious foods. And now comes in the point where the manufacture of "Bovril" comes to the front. The basis of bovril is the extract of meat in question, but to it is added what is being prepared at another part of the building. The lean of the best oxen is selected, and carefully freed from all visible tendon, cartilage, fat, and water. The reader may be surprised to know that in lean beef there is about 75 per cent of pure water, and as there must be a great deal of waste before the selected beef is procured, it takes many pounds of the ordinary article to produce one pound of the water-freed product. The process of evaporating the water is somewhat complicated. The result, however, is the production of albumen and fibrin in a granulated and

practically water-free form; and in this state they are packed in hermetically-sealed tins, and forwarded to the company's premises in London, where they are worked into bovril.

As has been already stated, there is no greater popular fallacy than that which places extract of meat and beef-tea in the category of nutrients, or foods that will sustain life or make flesh in the human system, and few who have not given dietetics a special study are aware that meat extracts are simple stimulants, acting upon the nervous system, giving it a degree of exhilaration and liveliness, but without any power of recuperating or building up the tissues. In brief, beef-tea is poker, nutriment is fuel, and heat can no more be obtained from a poker than the body can be nourished on ordinary extract of meat or beef-tea. What is wanted for the fire is fuel; what is wanted for the body are the ingredients of which the body is composed, and they are the aforesaid albumen and fibrin. There are the chemical constituents of albumen and fibrin in grass, but even were we capable of assimilating them we should be kept half our waking hours in the consumption of grass to obtain from it the amount necessary. Nature, however, has elaborated a process by which the ox munches the grass in his abundant leisure, and the ox supplies us with the perfected albumen and fibrin, minus the enormous amount of waste which the grass contains. The ox has made for us beef, which is chemically the same as the flesh from our own bodies. It may be divided into two parts—fluid and solid. The fluid is water, holding in suspension a variety of ingredients which give flavour and odour to beef. The muscular tissue is impregnated with a proteid fluid in which are met a variety of other substances, such as kreatin, kreatinin, hypoxanthin, inosite or muscle-sugar, lactic acid, and salts such as chloride of potassium and phosphate of magnesium.

When obtained cold, muscle juice also contains soluble albumen identical with that in white of egg, and coagulating at 73° C.; but as boiling is essential to the manufacture of extract, this albumen is entirely coagulated, and for purposes of preservation must be entirely strained off. It will thus be seen that nothing is left in the extract which can be regarded as food, and that what is required to make it food is the albumen, fibrin, and kindred substances previously removed.

There is another beef preparation which stands in the first place, the method of preparing which differs from all others in that it is an imitation of the actual digestive process. This

is the dissolved meat of Dr. Leube, and, as it is not patented, directions for making it are given. 1000 grammes (or any other weight) of beef, free from fat or bone, are chopped fine, and put into an earthenware or porcelain jar, with their own weight of water and 2 per cent of pure hydrochloric acid. The jar is then placed in a Papin's digester, fast closed, and digested for 12 to 15 hours; during the earlier part of the time the apparatus is occasionally opened and its contents stirred. The mass is then taken out of the jar, and rubbed or beaten in a mortar to the consistence of a paste, returned to the digester, and kept heated under pressure for 15 to 20 hours. It is now taken out, neutralized with carbonate of soda, thus forming common salt, moistened with water to form a fluid like gruel, and divided into four rations, which are given to the patients either pure or with crushed biscuit and milk. It makes an excellent soup.

With regard to the **physiology of proteids**, this much is obvious, that since all active tissues contain nitrogen, the materials for their upkeep must be nitrogenous also. Since the muscles are the most active organs of the body, and constitute nearly half its weight, proteids used to be called "flesh-formers". In the body, however, albumen occurs not only in the solid tissues, but in the blood and other vehicles of nutriment, and this tissue, or "fixed" or **organic albumen**, is very little affected in the daily exchange of products, only to the extent of 1 per cent or so, while the albumen of the nutritive fluids, hence called **circulating albumen**, is decomposed much more readily, to the extent of about 70 per cent in the twenty-four hours. Certain diseases disturb the normal balance of organic and circulating albumen, and in these the system itself is enfeebled, the albumen necessary for vital action being drawn from the tissues, and more especially from the muscles, producing a "wasting" action or "decline".

Within the body proteids undergo a complex series of decompositions, gradually becoming oxidized and simpler in structure, till as an end product they form *urea*, in which shape most of the nitrogenous waste leaves the body. This is especially true of gelatin and its allies, which have not the same tissue-forming value as albumen, though containing more nitrogen. They, however, pass very readily into "circulating" albumen, and in this way jellies, &c., may serve as tissue-saving material. All proteids are therefore concerned in the absorption and utilization of oxygen.

It is now absolutely clear that proteids may form fat. Fatty degeneration in muscle is an example of a nitrogenous substance becoming changed into fat, and it is well known that if a nursing mother wishes to enrich her milk that end is best attained by increasing her allowance, not of fatty or sugary matter, but of lean meat.

By experiments on animals it has also been proved that pure proteid matter may be converted into sugar and glycogen. This is seen in diabetes, where the sugar found in the urine is out of all proportion to the carbohydrates in the food, and so must have been formed either out of nitrogenous foods or at the expense of the nitrogenous tissues themselves.

COMPARATIVE VIEW OF THE TRUE PROTEIDS.

I. Native **Albumens**, soluble in water and dilute saline solutions; coagulated by heat.	Serum albumen, in blood. Egg albumen. Muscle albumen, extracted by water. Lact-albumen.	These are all partly dissolved when meat is boiled with salt.
II. **Globulins**, insoluble in water, but soluble in dilute saline solutions; coagulated by heat.	Vitellin, in yolk of egg. Para-globulin or serum-globulin, in blood. Fibrinogen, forming fibrin. Myosinogen, forming myosin. Caseinogen, forming casein. Globin. in hæmoglobin of the blood.	
III. Derived Albumens or **Albuminates**, insoluble in water, soluble in dilute saline solutions; not coagulated by heat.	Acid albumen or syntonin. Alkali-albumen.	
IV. **Proteoses.**	Bodies intermediate between proteids and peptones, formed in the digestive processes.	
V. **Peptones.**		
VI. **Coagulated Proteids.**	Coagulated by heat. Coagulated by ferments; fibrin, myosin, casein.	

SUMMARY.

1. Foods contain carbon, nitrogen, hydrogen, oxygen, &c., in the form of compounds called proximate principles.
2. The chief proximate principles are classified as proteids, fats, carbohydrates, salts, and water.
3. Proteids contain: nitrogen, 16; carbon, 54; oxygen, 22; hydrogen, 7; and sulphur, 1 per cent; and are thus called nitrogenous foods.
4. They are subdivided into albumens, gelatines, and extractives.

5. Albumens have the following functions:—
   (*a*) They are necessary for the repair of tissue waste.
   (*b*) They liberate a small amount of energy by oxidation, and thus control the utilization of oxygen within the system.
   (*c*) Under special circumstances, they *may* form fat, and even *sugar*.
   (*d*) In the process of digestion they become *peptones*.
   (*e*) Albuminous waste leaves the body as *urea*.
6. Gelatines fulfil the same functions, but less perfectly, and they tend to pass into the "circulating" rather than the "tissue" albumen, thus sparing tissue-consumption.
7. Extractives act upon the nervous system, and while not foods themselves, are essential as regulators of digestion and assimilation, especially of gelatines.

Lesson 6.—FATS.

The second great class of food-stuffs comprises the fats and oils. There is no distinction between fat and oil; fat is solidified oil, as oil is melted fat. Moreover, in the living body both are in the liquid condition, and it is only after death that they solidify, forming tallow, suet, &c. In the body the oil is inclosed within cells, consisting of ordinary connective-tissue corpuscles, and a mass of such cells held together by a slight framework of connective tissue constitutes fatty or **adipose tissue.** The cell-walls are composed of albuminous matter, and in order to release the oil within these walls must either be dissolved by such chemical agents as the digestive juices, or ruptured by heat and pressure; all three processes occur in the preliminary digestion of fats. Adipose tissue is widely distributed in the body, occurring chiefly under the skin, and around certain organs, notably the kidney, heart, and intestines. Since fat constitutes a storehouse of reserve material its bulk varies with the demands upon it, and in starvation it is greatly reduced.

The chemistry of fats may be studied by examining tallow. If tallow be melted in a test-tube, and caustic soda or carbonate of soda added, there is formed a white curdy mass, which separates readily on adding salt, and finally floats on a clear but thickish liquid. That liquid is **glycerin,** the curdy mass is a **soap,** and the fat is said to be *saponified.* The

chemical action here is one of displacement, the base glycerin having been displaced by the base soda. In order to discover what else is in the oil, take some soap solution and add a little hydrochloric acid; another white deposit appears, which this time settles to the bottom. This is another case of displacement, the hydrochloric acid having displaced the acid of the soap, that is, of the fat from which the soap was made. These acids form a group known as the **fatty acids**, and the chief among them are stearic, oleic, and palmitic acids. Chemically speaking, therefore, a fat is a salt containing a fatty acid and a base. The acid may be any of the fatty acids, but the base is always glycerin. The changes in the above experiments may be represented thus:—

$$\text{Fat}=\left\{\begin{array}{c}\text{Fatty Acid}\\ +\\ \text{Glycerine}\end{array}\right. \textit{ and } \text{ Soda } \textit{ form } \text{ Soap}=\left\{\begin{array}{c}\text{Fatty Acid}\\ +\\ \text{Soda}\end{array}\right. \textit{ and } \text{ Glycerine.}$$

$$\text{Soap}=\left\{\begin{array}{c}\text{Fatty Acid}\\ +\\ \text{Soda}\end{array}\right. \textit{ and } \begin{array}{c}\text{Hydrochloric}\\ \text{Acid}\end{array} \textit{ form } \begin{array}{c}\text{Common}\\ \text{Salt}\end{array}=\left\{\begin{array}{c}\text{Hydrochloric}\\ \text{Acid}\\ +\\ \text{Soda}\end{array}\right. \textit{ and } \begin{array}{c}\text{Fatty}\\ \text{Acid.}\end{array}$$

By the action of superheated steam, and also by certain digestive juices, fats can be decomposed at once into fatty acid and glycerin. These changes are effected within the body by fat-splitting and soap-forming ferments contained in the digestive fluids of the intestine.

Any natural fat such as butter is not a simple fat, but is composed of several fatty acids united with glycerin, being thus a mixture of fats. The common simple fats are stearin, olein, and palmitin, all found in animal, and the last two in vegetable foods. Stearin is the chief constituent of mutton fat and suet; its acid is stearic acid, and it might be called either stearate of glycerin or stearin glyceride; similarly, olein contains oleic acid, and palmitin found in palm-oil, palmitic acid. Olein is the chief constituent of olive-oil, and is not only itself liquid, but keeps the other fats in solution. Lard contains a great deal of olein, and thus is soft and buttery, while suet is rich in stearin and correspondingly firmer.

In commercial soap-making the base chosen is either soda or potash, the latter forms *soft soaps*, the former *hard soaps*, the names in this case referring solely to consistence.

Fats consist of carbon, 79 parts; hydrogen, 11; and oxygen, 10 per cent; and are thus non-nitrogenous. There is a remarkable nitrogenous fat called *lecithin*, found in nervous tissue and in yolk of egg, containing phosphorus as well as

nitrogen. Fats were formerly called *hydrocarbons*, oleaginous foods, and heat-givers; but the name hydrocarbon is properly restricted to substances like turpentine, benzine, camphor, &c., which consist of carbon and hydrogen only. They are mostly insoluble in water, though water is always associated with them; and the sputtering that occurs in frying is not due to the boiling of the fat, but solely to the escape of water, which boils at a much lower temperature than fat. When all the water has been expelled fat boils quietly until it reaches the point of decomposition, when it begins to smoke. Cooking by fat will be farther treated in the lesson on frying. There is one fat remarkable for being soluble in water; this is wool-fat, or *lanolin*, and it enters largely into the composition of toilet soaps, such as vinolia and maioline, which are thus super-fatted.

Although fats contain oxygen, the proportion of the latter is too small to oxidize even the hydrogen of them, to say nothing of the carbon, so that nearly the whole of these two elements is available as fuel, and on this account fats were formerly called heat-givers. As has been seen, all foods are heat-givers in so far as they are the subjects of direct chemical action; but the name is so far applicable to the fats on account of their great value as bodily fuel. An accumulation of adipose tissue within the body is thus a storehouse of energy, a reserve fund which may be drawn upon in cold, famine, or increased exertion. The appetite recognizes this by favouring fatty foods in colder weather, and the Eskimo and Laplander relish oleaginous dishes the very mention of which is sufficient to excite nausea in the inhabitants of warmer climes.

The **physiology of fats** is not just so clear as their behaviour in the laboratory. Since fat is a fuel so rich and so easily available, it is oxidized in preference to the albuminous foods and tissues, and so has an albumen-sparing action. Glycerine by itself, however, has no such action; it rather increases the amount of albuminous waste, as seen in the urine. By far the most digestible form of fat is ordinary fresh butter.

SUMMARY.

1. Fats contain about 80 per cent of carbon, and 10 per cent of available hydrogen.

2. They thus stand first among food-stuffs in respect of heat and energy obtained.

3. They all contain a fatty acid and glycerine.
4. Soaps contain a fatty acid and soda or potash.
5. Both fat-splitting and soap-forming actions occur in digestion.
6. Adipose tissue consists of albuminous cells filled with fat.

Lesson 7.—CARBOHYDRATES. STARCH.

We now come to the great division of food-stuffs known as **Carbohydrates**. As the name implies, they consist of carbon, hydrogen, and oxygen, the last two being in the proportion to form water; that is, the hydrogen may be regarded as already oxidized, leaving only the carbon available as a source of energy. Three subdivisions of this class are generally recognized, namely:—

Sucroses.	*Glucoses.*	*Amyloses.*
Cane-sugar.	Dextrose or grape-sugar.	Starch.
Lactose or milk-sugar.	Levulose or fruit-sugar.	Dextrin.
Maltose or sugar of malt.		Cellulose.
		Gums.
		Glycogen.

Let us take, to begin with, the *amyloses* or **Starches**, of which ordinary starch will serve as the type. When freshly made it is a white powder, structureless to the eye, but seen under the microscope to consist of minute grains, oval or pear-shaped.

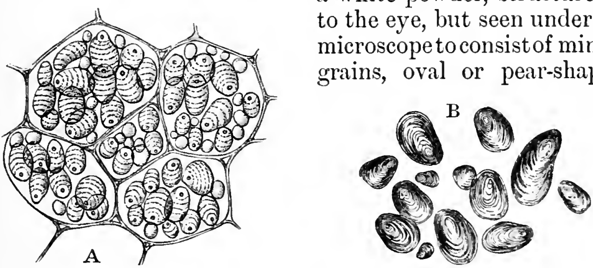


Fig. 3.—A, Cells from Potato Tuber showing Starch Granules. B, Starch Grains of Potato more highly magnified.

If a raw potato be cut in two, pared round the edges to avoid dirt, and the faces rubbed together with a little water, the latter will become milky. On examining a drop of this under the microscope, the milkiness is seen to be due to the presence of innumerable ovoid bodies, with a faint onion-like structure. These are grains of potato starch, and they were inclosed

within the cells of the vegetable, but by rubbing, some of the cells have been broken, and the grains liberated in consequence. As the diagram shows, the great mass of the potato is formed of cells containing starch grains, and a similar structure characterizes wheat, oats, rice, and all the farinaceous foods.

Raw starch is insoluble in cold water, but dissolves in boiling water, forming a paste on cooling. It is thus not a *crystalline*, but a *colloid* or glue-like body. When a little iodine solution is added to starch the latter becomes deep-blue, owing to the formation of iodide of starch; the blue colour disappears on heating, but reappears on cooling. This is a valuable test for starch, and may be used for demonstrating its presence in a great many food-stuffs.

If now a little dry starch be heated in a pan, the starch turns yellowish, just like bread when toasted, and if the heating be arrested at this stage, it will be found that a new substance has been formed called **Dextrin**. The same change would be accomplished more rapidly by the addition of a little hydrochloric or nitric acid. This differs from starch in being very soluble in water, forming what is called British Gum, so much used for postage stamps, envelopes, &c. Although it has the same chemical composition as starch, it strikes a reddish-brown with iodine instead of dark-blue.

Now take a little boiled rice, and after applying the iodine test to a sample to demonstrate the presence of starch, add some saliva, or chew the rice for a few minutes. On again applying the iodine test, instead of the starch-blue there is got a purple, or even no colour at all. This instructive experiment shows that *digestion begins in the mouth*, and that by means of saliva starchy matters are converted into dextrin, or even further, into a substance which gives no colour with iodine. This digestive change is due to a substance in the saliva called **Ptyalin**, one of the numerous class of digestive ferments. It acts upon starch alone, converting it successively into dextrin and maltose, or sugar of malt. This explains why dry toast and rusks are so suitable for children and invalids, for in the process of manufacture nearly all the starch in those is altered to dextrin, thus saving a stage in digestion. In infants ptyalin is not formed in the saliva for several months after birth, so that infants should in no case get starchy foods, such as arrowroot, until they are at least eight months old, since in them neither the saliva nor any other digestive juice can accomplish the necessary conversion

of starch into sugar. This action of ptyalin resembles that of diastase or extract of malt, hence it is called a diastatic or amylotic ferment, from its power of altering starch. As will be seen later on, ptyalin is not the only diastatic ferment in digestion. If the rice experiment be tried, using raw rice, the action of the saliva will be very much retarded; in the case of raw starch the ferment acts only after two or three hours, whereas upon boiled starch it acts in as many minutes, especially in presence of a little salt. This shows, by the way, the necessity of cooking farinaceous foods, and also the importance of giving food copious salivation, say to the extent of the Gladstonian thirty bites.

Dextrin, or British gum, is now generally used for adhesive purposes instead of the more expensive gum arabic. This latter is a natural gum, and similar substances are found in all vegetable food-stuffs.

Composed of the same elements as starch, and chemically identical with it, is the very important substance **Cellulose**, which constitutes the bulk of vegetable fibre. Cotton-wool may be taken as almost pure cellulose, and paper, which is just felted vegetable fibre, is another familiar example. When a plant is young its cellulose can be digested readily by herbivorous animals, and to a slight extent by man; but as the plant grows older the cellulose becomes more woody in structure, and often gets enveloped in resinous material, so that it is as indigestible as paper or saw-dust. Herbivorous animals have a preparatory stomach specially constructed for the digestion of herbs, a process in which fermentation bulks very largely; in the absence of such special natural appliances man has to fall back on the resources of chemistry. Although the conversion of woody fibre into sugar is familiar to everyone in the ripening of fruit, and is so far imitated by the brewer in the process of malting, still the formation of sugar out of cotton-wool, linen rags, and paper, to say nothing of saw-dust, is at present a chemical curiosity, and men are still content to get their cellulose at second hand in the shape of mutton and beef.

Glycogen, or liver starch, will be considered in the lesson on the Liver.

SUMMARY.

1. Carbohydrates contain carbon, hydrogen, oxygen; the last two in the proportion to form water.

2. They are subdivided into starches, sucroses, and glucoses.
3. Starch is obtained from all parts of plants, notably the root, stem, and seeds, and constitutes the great bulk of farinaceous foods.
4. Starch is converted into dextrin by heating, and by the action of acids.
5. Ptyalin and other diastatic ferments convert it first into dextrin, then into maltose or sugar of malt.
6. Digestion thus begins in the mouth.
7. Cellulose, unless when young, is indigestible.

Lesson 8.—SUGARS.

In the preceding lesson we had examples of the conversion of starch into **Sugar** in the ripening of fruits, in the process of malting, and in salivary digestion. By using sugar stored up by ripe plants another stage in the digestion of vegetables will be saved, as it were. Sugar occurs in nearly all plants, but is specially obtained from the sugar-cane, beet-root, and maple-tree. The canes are crushed between rollers, and the juice after being freed as much as possible from vegetable fibre is evaporated in a vacuum-pan, and in this way there are obtained large crystals of raw sugar, which have now to be refined to get rid of their colouring matter. The form of sugar obtained from cane or beet is *sucrose* or cane-sugar; the kind found in milk, and of the same composition, is *lactose* or milk-sugar; while *maltose* or malt-sugar is formed in the process of malting. In this the grain is roasted in a kiln at a moderate temperature till it shows signs of sprouting, when the temperature is raised to arrest further growth. The grain, now called malt, is now brownish, part of the starch having been transformed into dextrin, and it is distinctly sweeter in taste, showing that a good deal of the starch has been further changed into sugar. The object of malting is of course to convert the insoluble starch into sugar and dextrin, which are both soluble in water.

These three sugars, cane-sugar, lactose, and maltose, constitute one division of the carbohydrates called the **Sucroses** or Saccharoses. They all have the same chemical composition, namely:—carbon 42·1, hydrogen 6·4, oxygen 51·5 parts per cent.

Ordinary cane-sugar dissolves readily in cold water in the proportion by weight of three of sugar to one of water. Hot

water dissolves much larger quantities, and if a hot saturated solution be slowly cooled, large yellowish crystals will be formed, well known as *sugar-candy*. If, however, a sugar solution be heated till the temperature rises to 170° or 180° C. (365° F.), a molecular change occurs; the substance loses its crystalline character, and forms on cooling a yellowish glassy mass called *barley-sugar*. Sugar is thus *allotropic*, that is, capable of assuming different forms, crystalline and colloid, while retaining the same chemical composition.

It will be interesting to watch the behaviour of sugar heated in a dry test-tube. When the temperature rises to 160° C. (320° F.) the crystals melt, then at 180° C. the sugar assumes the colloid condition of barley-sugar, then at about 216° C. (420° F.) the sugar appears to lose more water and it becomes burnt-sugar or *caramel*, while by a stronger heat it is completely carbonized. Caramel has a dark-brown colour, a peculiar smell and bitterish taste, not unlike that of molasses or bread-crust. It further differs from ordinary sugar in not being fermentible, and, indeed, rather tends to kill germs. It dissolves very easily in water, and is much used as a colouring matter for brandy, whisky, and other naturally colourless distillates, as well as for colouring soups. Caramel is just as nutritious as sugar itself. As was seen in the first lesson, it is produced along with dextrin in toasting bread; it occurs largely in the crust of well-fired loaves, and indeed whenever any carbohydrate or fat is strongly heated. It forms the basis of "beurre noire" and other brown sauces, and is formed in the grilling or roasting of meat and fish, though in the latter case it will be accompanied by dextrin from the flour or bread-crumbs usually put on the fish, and there will very likely be some carbon formed as well.

Besides ordinary sugar there is another important class of sugars known as **Glucoses**, also consisting of carbon, hydrogen, and oxygen, but in slightly different proportions, as follows:—carbon 40, hydrogen 6·7, oxygen 53·3 per cent. The chief varieties of glucose are *dextrose* or *grape-sugar*, and *levulose* or *fruit-sugar*. Both are contained in honey, and may be obtained by the following method: Shake up some honey with its own bulk of alcohol, allow the sediment to settle, then decant off the alcohol and repeat with fresh spirit. In this way the levulose, which is pretty soluble in alcohol, is dissolved out, while the dextrose, soluble with difficulty in alcohol, is left behind. These two sugars get their names from their respective

actions on polarized light, dextrose or "right-handed" sugar rotating the ray to the right, while levulose or "left-handed" sugar rotates it more strongly to the left. They commonly occur together in fruits, and a mixture of equal proportions forms *invert* sugar, so called because, owing to the stronger action of levulose, the rotation of polarized light is to the left, whereas cane-sugar rotates the ray to the right. Ordinary cane-sugar is "inverted", that is, resolved into equal parts of dextrose and levulose, a mixture of glucoses, by boiling with any mineral acid; long-continued boiling alone is sufficient to accomplish the inversion, and since glucose is only about three-fifths as sweet as cane-sugar the result is an apparent loss of sweetness. When tea is made on the large scale the sugar is often added to the water before infusing, and when this is done more sugar is required to make up for the loss of sweetening due to inversion. In the Royal Navy, where tea was prepared in this way, the men said that the sugar evaporated. A similar action occurs in the manufacture of jams and jellies, where the process is hastened by the presence of the several vegetable acids in the fruit used, and the common English practice of serving sugar *with* tarts seems to be justified on this score, though the Scottish plan of cooking the tarts with sugar certainly gives a more palatable dish.

The same change of cane-sugar into a mixture of the two glucoses takes place within the body, owing to the action of various "inverting" ferments, and so all carbohydrates whatsoever are ultimately converted into glucose, which would thus seem to be the physiological sugar. As already stated, it is not so sweet as cane-sugar, neither so crystalline, nor so soluble in water, yet all starches and sugars pass into this form, and as such enter the blood.

Glucose further differs from cane-sugar in two important respects, which are utilized as tests for its detection, say in urine. When yeast is mixed with a solution of glucose, and the mixture allowed to stand in a warm place, **fermentation** occurs. The yeast, which is a kind of fungus, by its vital action decomposes the glucose, forming alcohol and liberating carbonic acid gas, and producing, in short, a beer. Ferments like yeast are called organized ferments, to distinguish them from the soluble or unorganized ferments, such as ptyalin, which occur naturally in the several digestive juices. Cane-sugar does not ferment as readily, as it has first to be converted into glucose by the action of the yeast. The fermentation test

is often used to detect glucose in diabetic urine, since 100 parts by weight of carbonic acid gas evolved correspond to 204·54 parts of sugar.

The other test feature of glucose is the property which it possesses of "reducing", or depriving of oxygen, certain metallic oxides in alkaline solutions. When caustic potash is added to copper sulphate and the solution boiled, a black oxide of copper is produced; but if glucose be added to begin with, there will be obtained an orange oxide containing only half the oxygen, showing that the black oxide has been reduced by the glucose. Cane-sugar does not show this result unless upon long-continued boiling.

There is another kind of fermentation familiar to all in the souring of milk. In this case it is the lactose or milk-sugar which is acted on by a bacillus present in the air, which converts it into lactic acid. A similar change takes place in the stomach; but in dyspepsia this may be followed up by another fermentation, whereby the lactic acid may be further decomposed into butyric acid and carbonic acid gas. It is this butyric-acid fermentation which chiefly gives rise to "wind" in the stomach. The souring of beer presents another familiar example of one fermentation succeeding another. Beer is produced by an alcoholic ferment, yeast, acting upon maltose; but by the action of an aërial bacillus that alcohol is further changed into acetic acid. Similarly the lactic fermentation in and about the teeth prepares the way for caries. The whole subject of fermentation will be dealt with later on, under the several heads of alcohol, milk, &c.

SUMMARY.

1. The term sugar comprises sucroses and glucoses.
2. Sucroses include cane-sugar, malt-sugar, and milk-sugar.
3. Glucoses comprise dextrose and levulose.
4. Cane-sugar becomes "invert sugar", a mixture of glucoses, on adding acids or on long-continued boiling.
5. All carbohydrates become dextrose in the course of digestion.
6. Sugar is fermentable by various fungi.

Lesson 9.—SALTS.

In order to understand the part which **Salts** play in food-stuffs it will be advisable to consider first the part they play within the body itself, and this will be made clear by the following tables:—

Solid Tissues.

Percentage of Substance in Ash.	Bone.	Muscle.	Brain.	Liver.	Lungs.	Spleen.
Sodium chloride, ...	—	10·59	4·74	—	13·0	—
Potassium ,, ...	—	—	—	—	—	—
Soda, ...	—	2·35	10·69	14·51	19·5	44·33
Potash,...	—	34·40	34·42	25·23	1·3	9·60
Lime, ...	37·58	1·99	0·77	3·61	1·9	7·48
Magnesia, ...	1·22	1·45	1·23	0·20	1·9	0·49
Iron oxide, ...	—	—	—	2·74	3·2	7·28
Chlorine, ...	—	—	—	2·58	—	—
Fluorine, ...	1·66	—	—	—	—	—
Phosphoric acid (free), ...	—	—	9·15	—	—	—
,, ,, (combined),	53·31	48·13	39·02	50·18	48·5	27·10
Sulphuric acid, ...	—	—	0·75	0·92	1·4	2·54
Carbonic acid, ...	5·47	—	—	—	—	—
Silicic acid, ...	—	0·81	0·12	0·27	—	0·17
Phosphate of iron, ...	—	—	1·23	—	—	—

Fluids.

Percentage of Substance in Ash.	Blood.	Blood Serum.	Blood-clot.	Lymph.	Urine.	Milk.	Bile.	Fæces.
Sodium chloride,	58·81	72·88	17·36	74·48	67·28	10·73	27·70	4·33
Potassium ,,	—	—	29·87	—	—	26·33	—	—
Soda, ...	4·15	12·93	3·55	10·35	1·33	—	36·73	5·07
Potash, ...	11·97	2·95	22·36	3·25	13·64	21·44	4·80	6·10
Lime, ...	1·76	2·28	2·58	0·97	1·15	18·78	1·43	26·40
Magnesia, ...	1·12	0·27	0·53	0·26	1·34	0·87	0·53	10·54
Iron oxide, ...	8·37	0·26	10·48	0·50	—	0·10	0·33	2·50
Chlorine, ...	—	—	—	—	—	—	—	—
Fluorine, ...	—	—	—	—	—	—	—	—
Phosphoric acid (total), ...	10·23	1·73	10·64	1·09	11·21	19·00	10·45	36·03
Sulphuric acid,...	1·67	2·10	0·09	—	—	2·64	6·39	—
Carbonic acid, ...	1·19	4·40	2·17	8·20	—	—	11·26	—
Silicic acid, ...	—	0·20	0·42	1·27	4·06	—	0·36	3·13

It must be explained that the substances mentioned are only those which appear in chemical analysis, generally oxides due to ignition, and found as **ash**, though they do not appear in that form in the tissues. Thus, although lime appears in bone

it is not to be supposed that it exists in bone as lime; on the contrary, the calcium of the lime found is combined with the organic matter of the bone, but in the analysis appears as ash by ignition and consequent oxidation. So the phosphoric acid and phosphates do not occur as such in the body; they are the products of the oxidation of phosphorus, which in the body is found in proteid matter. In a similar way the sulphur of proteid matter appears in the analysis as sulphuric acid.

From these figures it will be seen that the most important mineral substances in the body are soda, potash, lime, and phosphoric acid. When bones are burned in a closed vessel they are of course carbonized, being converted into animal charcoal; but if burned in an open fire the carbonaceous materials are all burned away, leaving bone-ash, which is, roughly speaking, a **phosphate** of lime. It is this very substance which, on further treatment, yields the "superphosphate" of the farmer, a valuable wheat manure. Wheaten flour contains four per cent of salts, chiefly phosphates of lime and magnesia, and the English "wheat belt" follows the line of phosphatic rocks. Phosphate of lime is the most abundant substance in the ash of the body, as it forms more than one-half of our bones. It is derived from food in the form of carbonate and bicarbonate of lime, which by chemical exchange becomes converted within the body into phosphate.

The muscles as well as the bones are rich in phosphates, this time of potash and soda, and as the muscles and bones together make up three-quarters of the body, the importance of these substances will at once be perceived.

Phosphorus is popularly associated with the brain and nervous system. Part of the phosphorus in these organs occurs in the curious nitrogenous fat called lecithin, found also in yolk of egg. The table further shows that phosphoric waste is expelled from the body by the bowels rather than by the kidneys, in the proportion of fully 5:1. When phosphorus is burnt in air, it is oxidized and forms phosphoric acid, the salts of which are phosphates; in the same way, lime is the oxidized product of calcium salts. To give a person phosphates or lime with the idea of supplying him with a fresh stock of energy, is to give him materials already fully oxidized, and this has been aptly compared to feeding a fire with ashes. There are, however, other compounds of phosphorus, &c., not fully oxidized, such as phosphites, and especially *hypophosphites*, and it is these last which enter into many "chemical foods".

Next in importance to phosphorus as a mineral element comes calcium, the element in **Lime**. Our supplies of this substance are naturally obtained from vegetable and animal foods, as well as from the lime compounds in most drinking-waters. The popular belief is that a very pure water, like that of Loch Katrine, is too deficient in lime salts, and that therefore the bones of the young citizens of Glasgow suffer in consequence. It is no uncommon practice to blame nature for the results of one's own ignorance and folly, and in the present instance the presence of rickets and bandy-legs among the children of the poorer classes is due to mal-nutrition, and especially to the fact that tea has almost entirely ousted the national oatmeal.

If compounds of lime be denied in sufficient quantity, then it is withdrawn from other tissues, particularly the bones and muscles, to supply the more active parts of the organism, exactly as happens in nitrogen starvation. All tissues contain lime, and it seems essential to cell-growth. The presence of lime salts contributes largely to the coagulation of blood and milk.

The two leading alkalies, **Potash** and **Soda**, though chemically allied, play very different rôles in the body, and do not seem to be interchangeable. Speaking generally, potash is most abundant in the solid tissues, and soda in the fluids. Soda is more abundant in the early stages of life, and bulks largely in the spleen, liver, and bile; it takes the leading position in serum, the liquid part of the blood, while the more solid clot is richer in potash. The commonest soda compound is sodium chloride or common salt, which exists in all the tissues. It is very soluble in water, and hence leaves the body largely in urine, the daily loss from this source requiring to be met by taking salt in food. Another use of common salt, and of chlorides generally, is to supply the cells of the stomach glands with the materials of hydrochloric acid, the acid found in gastric juice. Potash salts are curiously deficient in lung tissue.

The **Vegetable Acids**, oxalic, tartaric, citric, and malic acids, along with lactic acid from butter-milk and acetic acid in vinegar, are decomposed within the system, forming alkaline carbonates, and thus serve to preserve the alkalinity of the blood. Combined with potash and soda these vegetable acids are found in great abundance in all unripe fruits, and in the process of ripening become partly converted into sugars. Certain fruits are characterized by certain acids; thus grapes contain tartaric acid; apples, malic acid (Lat. *malum*, an apple); lemons,

oranges, and the citron tribe generally, citric acid; while oxalic acid, commonly called salts of sorrel, occurs in tomatoes, rhubarb stalks, and the sorrels. All these acids consist of carbon, hydrogen, and oxygen, and, with the exception of acetic and lactic acids, have more oxygen than is required to oxidize their hydrogen into water. Their great function is not, however, to supply energy by oxidation, but to preserve the alkalinity of the blood, and to act as preventives to scurvy, or antiscorbutics. It may seem like carrying coals to Newcastle to cure acidity in the stomach by drinking lemon-juice, to "kill" an acid by taking more acid, but the fact remains, and the explanation is given above.

Fruits and green vegetables are eaten, not so much for any nourishment they contain as for their water and salts. This is the true function of a salad, and all methods of cooking vegetables should be subordinated to that end. Dry salads contain 23 per cent of salts, which strongly resemble those of the blood. The Irish are quite right, therefore, in regarding as heresy any method of boiling potatoes otherwise than in their "jackets", since in the potato the cells particularly rich in potash salts lie underneath the skin, and are the first ingredients to be dissolved out when the latter is broken. The importance of fresh vegetables in preventing scurvy is well known. Most vegetables contain from two to eight times as much potash as soda, so that herbivora require to preserve the balance of alkalies by taking salt in their food.

Besides sugar and vegetable acids, fruits contain *pectin* or vegetable jelly, and an insoluble substance called *pectose*, which by the action of a ferment in the fruit itself is changed into pectin. Like the fruit acids these consist of carbon, hydrogen, and oxygen, the latter in defect.

Rheumatism is characterized by an excess of lactic acid within the tissues, as gout is by uric acid. These acids decompose within the joints, forming carbonates of lime, or "chalkstones", and thus rendering motion extremely painful. In gout the preventive treatment aims at the formation of soluble urates by giving alkalies, especially lithia, the urates of which are very soluble in water.

Most of the other mineral substances, such as fluorine, will be considered as required, but **Iron** deserves special mention. The blood is rich in iron, and, as the figures show, it is especially the solid parts of the blood that contain it. It is to iron that blood owes its red colour, since that metal enters into the

composition of **hæmoglobin**, the substance in the red corpuscles which serves as oxygen-carrier to the tissues. As might be expected, those organs which have to do with decomposition of the blood corpuscles, namely the spleen and liver, are also very rich in iron, the spleen especially so. "The action of iron on the blood is almost unique; first, because its specific action is exerted, not upon the plasma or blood liquor, but upon the red corpuscles, and on these alone, not on any other tissue or organ. Iron has no specific action on the organs apart from the blood, and the *tonic* effect which it produces so satisfactorily appears to be entirely referable to its action on the blood. Abundance of oxygen is essential for every bodily and mental function; and the feeling of "tone", vigour, and mental fitness varies with the degree of oxygenation of the blood, *i.e.* with the quality of the blood as regards hæmoglobin" (Mitchell Bruce, *Therapeutic*).

The total quantity of iron in the body is very small, only 3 grams or 46 grains, so that the practice of taking excessive doses of iron pills, &c., almost warrants the sarcasm about treating the stomach like a blast-furnace, what with lime-water, charcoal biscuits, and iron compounds. The factor commonly neglected here is assimilation; and if these ingredients are to be supplied, it is much better to supply them in naturally-formed vegetable or animal tissue rather than as minerals.

SUMMARY.

1. Salts are essential as an ingredient in foods.
2. They serve various functions within the body; to help in the formation of bone, muscle, gastric juice, &c.
3. Salts of the vegetable acids are specially useful in preserving the alkalinity of the blood, and so preventing scurvy.
4. The solid tissues of the body are rich in potash and phosphates; the fluids, in soda and chlorides.
5. Iron has a specific action upon the solid parts of the blood.

Lesson 10.—WATER.

The last proximate principle in food-stuffs is **Water**. As has been seen, water is not an element but an oxide of hydrogen, and it is formed when any hydrogen compound burns in air.

This explains the curious fact that more water is removed from the body than is consumed in the food and drink. An adult uses daily in solid and liquid food from 70 to 90 ounces of water, or about 4 pints, whereas there is removed from the body by the lungs, skin, kidneys, and bowels more than 4½ pints, the excess having been formed by oxidation within the system. Water is required for two reasons; as a solvent, to aid in digestion, and for purposes of tissue-formation. Roughly speaking, about two-thirds of the whole body consists of water; it enters into the composition of every tissue—even such a hard substance as the enamel of the teeth containing a small amount, while saliva and sweat are almost entirely water. The amount of water in various tissues of the body is given by the following table in parts per 1000:—

Solids.				Liquids.			
Enamel,	2	Brain,	750	Blood,	791	Serum,	959
Dentine,	100	Muscle,	757	Bile,	864	Gastric juice,	973
Bone,	486	Spleen,	758	Milk,	891	Intestinal do.	975
Fat,	299	Connective,	790	Blood plasma,	901	Tears,	982
Cartilage,	550	Kidney,	827	Chyle,	928	Saliva,	995
Liver,	693	Vitreous humour,	987	Lymph,	958	Sweat,	995
Skin,	720						

The human body is constantly undergoing tissue change. Worn-out particles are cast aside from the system, while the new are ever being formed. Water has the power of increasing these tissue changes, which multiply the waste products, but at the same time they are renewed by its agency, giving rise to increased appetite, which in turn provides fresh nutriment. Persons but little accustomed to drink water are liable to have the waste products formed faster than they are removed. Any obstruction to the free working of natural laws at once produces disease, which, if once firmly seated, requires both time and money to cure. People accustomed to rising in the morning weak and languid will find the cause in the imperfect secretion of wastes, which many times may be remedied by drinking a full tumbler of water before retiring. This very materially assists in the process during the night, and leaves the tissue fresh and strong, and ready for the active work of the day. Hot water is one of the best remedial agents. A hot bath on going to bed, even in the hot nights of summer, is a better reliever of sleeplessness than many drugs. Inflated parts will subside under the continual poulticing of real hot water. Very hot water is a prompt checker of bleeding, and,

besides, if it is clean, as it should be, it aids in sterilizing our wounds. A riotous stomach will nearly always gratefully receive a glass or more of hot water.

Of the total quantity of water consumed, 70 to 90 ounces, from 50 to 80 ounces are taken in the liquid form, leaving the rest to be obtained from the various food-stuffs. Ordinary food contains fully half its own weight of water, and some vegetables and fruits contain upwards of 90 per cent, as will be seen by referring to the tables on pp. 189, 251.

Water best performs its digestive functions when pure, and its solvent powers are greatly increased by heating. Ordinary drinking-water contains in solution many substances, both solids and gases, and when these substances are present in such quantity as sensibly to affect the taste, colour, or smell of the water, it is often called a *mineral* water. Thus many waters contain iron, sulphuretted hydrogen, carbonic acid, salts of magnesia, potash, soda, and so on, and these are greatly used medicinally; they will be discussed in detail under the head, "Mineral Waters". The most important mineral substance in water is lime, and when lime or magnesia is present the result is "**hard water**". Lime itself is insoluble in water, but is converted into slaked lime or hydrated lime, which dissolves in a lot of water, forming lime-water, which may be used to illustrate experimentally the properties of hard waters. If a little soap solution be shaken up with some soft water or distilled water, a soft lather is produced which lasts for half an hour or so. Now add some lime-water to ordinary water till there is no taste, and shake it up with a little soap solution; a froth is formed, which soon subsides, leaving a dirty-white curdy mass suspended in the water. This is Clarke's soap test for hard water, and is explained as follows. As seen in lesson 6, soap is sodium stearate, and when shaken up with a lime salt, the soda of the soap is replaced by lime, forming calcium or lime stearate, while the soda remains in the water. Of course a hard water may be softened in this way, as by adding plenty of soap all the lime would be removed; but this is a most expensive method, and in most cases the same result can be attained by simpler means.

Now breathe through a tube into your lime-water; it turns milky, owing to the formation by the carbonic acid in the breath of carbonate of lime or chalk, insoluble in water. If a stream of carbonic acid gas be allowed to bubble through the lime-water for a few minutes, the milkiness increases in density

up to a certain point, then passes off, leaving the water clear as at first. On applying the soap test to a portion, it gives unmistakable signs of hardness, pointing to the presence in the solution of some salt of lime. The carbonate of lime which was at first produced is insoluble in water, but soluble in water containing carbonic acid gas, forming what might be called a bicarbonate of lime. Since this is the case, it is readily seen that if the carbonic acid gas were removed or otherwise "engaged", the lime salt would again show itself as a white powder. That this is really correct may be shown by boiling a little of this artificial hard water so as to expel the carbonic acid gas; the milkiness reappears as a deposit of white carbonate of lime. This is one way of **softening hard water**, and the carbonate of lime is deposited as a "fur" on the interior of kettles and other vessels, where its nature may be detected by effervescence on adding vinegar or any other acid.

There is, however, another process for softening hard water —Dr. **Clarke's process**,—in which, instead of expelling the carbonic acid as above, more lime is added, as quicklime or lime-water. The added lime "engages" the extra carbonic acid gas, and so not only comes down itself as carbonate of lime, but allows the original carbonate to come down also.

Hardness which can be removed by these methods is called **temporary hardness**, and it occurs in all cases where water is derived from calcareous rocks, such as chalk or limestone. Although these substances are insoluble in water, they are dissolved by water containing carbonic acid gas, as rain-water always does, and in limestone districts the water is often so highly charged with this gas as to present a sparkling appearance. This same brilliancy may be due to a very different cause, the carbonic acid being derived from decomposing animal matter, and such a water would be dangerous in the highest degree. When water percolates through rocks containing gypsum or sulphate of lime, part of the sulphate is dissolved and the water becomes hard; but since hardness due to sulphates cannot be removed by the foregoing methods, it is called **permanent hardness**. Hardness may be caused by magnesia or any of the alkaline earths, as well as lime.

On **boiling** water the first effect of the heat is to expel all dissolved gases. Water always contains dissolved air, and sometimes carbonic acid, sulphuretted hydrogen, and other gases, as in the sulphur springs of Harrogate It is from the

air dissolved in water that fish get their supplies of oxygen, not from the oxygen chemically combined in the water; and a fish placed in boiled water dies of suffocation, that is, of oxygen-starvation. After most of the air has been expelled, the further effect of heat is to turn the water into steam, but the conversion is not instantaneous. Large bubbles of steam collect at the bottom of the pan, but collapse without reaching the top. By and by they manage to rise higher and higher, showing that the temperature of the water is almost that of steam, and they finally come to the top and burst there. The water is now boiling, and no amount of further heating in an open pan will make it any hotter; it will make the ebullition more violent, since the steam is produced in greater quantities, but while this result is highly desirable in a locomotive boiler, kitchen utensils are designed for quite another purpose. Any heat beyond that required to keep the water simmering, *i.e.* just boiling and no more, is simply wasted, and in the great majority of culinary operations even that degree of heat is not needed.

The boiling-point of water is 100° Centigrade (212° F.), but it is affected by the density of the water, sea-water requiring a higher temperature. It is also affected very much by atmospheric pressure, rising when the pressure increases and falling when it is lowered. In the vacuum-pan of the sugar-refineries the pressure is lowered below that of the atmosphere, and thus sugar solutions can be evaporated at a temperature below that at which non-crystalline sugar forms. Conversely, when a cook wishes water to reach a higher boiling-point than usual, he employs a "digester", a pot the lid of which can be fastened down so as to raise the pressure within, and as a result the boiling-point. On the top of a hill water boils, *i.e.* passes into steam, much below the usual boiling-point. Piazzi Smyth tells how on the top of the peak of Teneriffe, after some vain attempts to boil potatoes leaving them as hard as ever, the cook of the party came to the conclusion that the potatoes were bewitched, or that the kettle, which was a new one, refused to cook them.

Boiling is an important method of purifying a suspected water, since almost all germs of disease likely to be found in water are killed by the application of boiling heat.

The following is a concise view of the various proximate principles in food-stuffs, showing their various uses in the body:—

CLASSIFICATION OF FOODS.

	Class.		Proximate principles.	Functions.
Nitrogenous.	I. **Proteids** C 54% N 16 H 7 O 22 S 1	1. *Albumens* proper C : N : : 2 : 7	Albumen Fibrin Myosin Syntonin Globulin Casein Glutin Legumin	Formation and repair of tissues. Regulation of absorption and utilization of oxygen. *May* form fat under special conditions. Partially converted into *peptones* in digestion.
		2. *Gelatins* C : N : : 2 : 5½	Gelatin Ossein Chondrin Keratin	Same functions as above but much less perfectly—about one-third only.
		3. *Extractives*		*Essential* as regulators of digestion and assimilation, especially with regard to gelatins.
Non-nitrogenous.	II. **Fats** C 79% H 11 O 10		Olein Stearin Palmitin	Supply of fatty tissues. Supply energy and heat by oxidation.
	III. **Carbohydrates** C 40%	1.	*Amyloses*: Starch, dextrine, cellulose, &c. *Sucroses*: Cane-sugar, maltose, lactose *Glucoses*: Dextrose, levulose	Supply of energy and heat by oxidation. Supply of fat by reduction. Converted into *dextrose* in digestion.
		2. *Vegetable acids*	Oxalic, tartaric, citric, and malic acids (excess of oxygen) Acetic and lactic acid (defect of oxygen)	Preserve alkalinity of the blood.
Mineral.	IV. **Salts**		Chlorides, phosphates, &c. of potassium, sodium, calcium, &c.	Various uses.
	V. **Water**			Formation of tissue. Solvent action.

SUMMARY.

1. Water occurs in all tissues, constituting two-thirds of the body.
2. It also occurs in all foods, to the extent of one-half or more.
3. Water is a tissue-former as well as a digestive solvent.
4. Hardness in water is due to compounds of lime or magnesia.
5. When hardness is due to *carbonates*, it is temporary, and can be removed by boiling the water or adding lime.
6. Hardness due to sulphates of lime, &c., is *permanent.*

Part III.—PHYSIOLOGY OF DIGESTION.

Lesson 11.—PROCESSES IN THE MOUTH.

As has been seen in preceding lessons, the body demands, both for its own support and for the liberation of energy, supply of carbon, hydrogen, oxygen, and nitrogen, along with smaller quantities of other elements. With the exception of oxygen, obtained directly from air, these elements are not presented to the body as such, but in those combinations, such as albumen, fat, starch, sugar, &c., called proximate principles. The union of elements to form these principles is already effected for us by plants, and now comes in the process of digestion, by which the organic materials supplied by plants are converted into a liquid form, with the view of being assimilated or formed into our own flesh and blood. This is the standing miracle which Life presents in even its lowest forms; the transformation of dead matter, either at first or second hand, with living tissue.

The **digestive processes** have for aim the solution of the several food-stuffs, and this is assisted, not merely by the water contained in all food-stuffs, and taken along with them as beverages, but by various digestive juices prepared within the organism itself, and exercising a chemico-vital action. It is usual to distinguish in digestion the following stages :—

1. Mastication,
2. Insalivation,
3. Swallowing,
4. Gastric digestion, or Chymification,
5. Intestinal digestion,
6. Absorption, and
7. Defæcation.

On entering the mouth, the food, if solid, comes under the action of the teeth, by which it is cut, torn, and bruised by a purely *mechanical* action, while all the time it is being moistened by the mucus of the mouth, and thoroughly mixed with saliva, which exercises upon it a certain *chemical* action. Mastication and insalivation thus go on together, and the person who "bolts" his food is not only ignoring the presence of teeth, and thrusting a crude mass upon the stomach, thus degrading it to a mere crop or gizzard, but is depriving himself of a stage in digestion, and storing up gastric trouble.

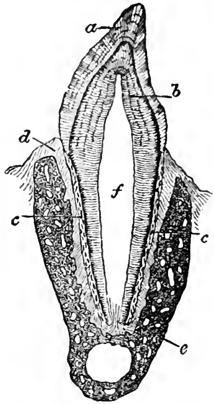


Fig. 4.—Structure of Tooth (magnified).

In the adult there are 32 **Teeth**, which have different shapes corresponding to their different functions. They are symmetrically arranged on either side of the middle line, and, from front to back, lie as follows:—2 incisors or cutting-teeth, chisel-shaped; 1 eye-tooth or canine, pointed, and adapted for tearing tough matters; 2 bicuspids, which get their name from their double crown; and 3 molars or grinders, the last generally known as "wisdom teeth". This relationship of the teeth is expressed by the dental formula—

$$\begin{array}{cccc|cccc} \text{M.} & \text{B.} & \text{C.} & \text{I.} & & & & \\ 3 & 2 & 1 & 2 & 2 & 1 & 2 & 3 \\ \hline 3 & 2 & 1 & 2 & 2 & 1 & 2 & 3 \end{array} = 32.$$

The milk-teeth, or first set, amount to only 20, arranged thus—

$$\begin{array}{ccc|ccc} \text{B.} & \text{C.} & \text{I.} & & & \\ 2 & 1 & 2 & 2 & 1 & 2 \\ \hline 2 & 1 & 2 & 2 & 1 & 2 \end{array}.$$

At the age of six, both sets are in the jaw with the exception of the wisdom teeth, so that the jaw then contains 48 teeth. From that time onwards the milk-teeth get gradually displaced by the permanent teeth, and their roots become absorbed.

A single tooth presents to the eye three distinct parts. The visible part is the *crown*, and it is covered with *enamel* (*a*), the hardest substance in the body, containing only 2 parts per 1000 of solids. The neck of the tooth is distinguished from

the fang, or *root*, which lies below the gum. The body of the tooth is composed of *dentine* (*b*), a substance resembling bone, but much harder, containing only 10 per 1000 of solids, while the fang is fixed into the jaw-bone (*e*) by a substance called the *cement* (*c*), practically the same as bone. The teeth are hollow, inclosing a space (*f*) filled with what is popularly called the "nerve", in reality a packing of pulpy tissue, containing, in addition to a twig of nerve, blood-vessels for the nourishment of the tooth. Very often there is formed on the teeth a deposit of "tartar", really carbonate of lime from the food, precipitated on the teeth much in the same way as fur is formed on a boiler. The teeth are attacked by mineral acids, and also by lactic acid, formed by fermentation out of milk-sugar, and when once an opening has been made in the enamel or the underlying dentine, the way is open for the ravages of caries. When salts of iron and similar tooth-solvents have to be taken medicinally they should be sucked through a tube, and the tooth-brush should be used *after* all meals.

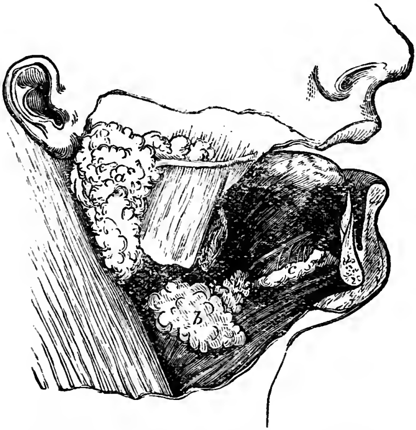


Fig. 5.—Salivary Glands. *a*, Parotid; *b*, submaxillary; *c*, sublingual.

While the mass of solid food is thus coming under the action of the teeth, it is at the same time getting thoroughly mixed with mucus from the mucous glands of the mouth, and **Saliva** from the salivary glands. The action of mucus is purely mechanical, serving to moisten the mass and lubricate it as a preparation for swallowing. More important is the action of saliva, since it is a digestive agent, converting starch into dextrin and malt-sugar. Saliva is supplied from three pairs of **salivary glands.** The largest of these is the *parotid* gland, placed, as its name implies, below its ear, and about the same size as that organ. It pours its contents into the roof of the mouth, at the second molar tooth. The *sub-maxillary* (Lat.

sub, under, and *maxilla*, the jaw) and sub-lingual (Lat. *lingua*, the tongue) lie in the lower jaw, and pour their saliva into the mouth by several openings under the tongue, where it may be seen swelling out when the appetite is excited by anything which "makes the teeth water".

Saliva is a clear watery fluid, slightly alkaline, and sticky from the mucus found in it. The inducement of a flow of saliva by the presence in the mouth of anything appetizing is a familiar example of "reflex action". Generally before vomiting there is a sudden flow of saliva. The total amount secreted daily is very considerable, and is estimated at from 7 to 50 ounces, the latter quantity being $2\frac{1}{2}$ pints! Tea has a marked effect upon the salivary glands, arresting their activity, and it has the same effect upon the similar juice from the pancreas; and as these are the only bodily juices capable of digesting starchy matters, it is obvious that the common practice of drinking tea at meals is a mistake, and that tea should be used as a stimulant only, three or four hours after meals.

Until a child begins to cut its teeth the amount of saliva is small, and it contains little or no ptyalin. Since the similar ferment in pancreatic juice is also undeveloped, infants must not be fed upon starchy foods like arrowroot; indeed, in France for a whole year a child is debarred by law from receiving solid food, except by medical prescription. The principle of supplying solid food in a soluble form has been embodied in such an infant food as Mellin's, in which all starchy matters are malted, *i.e.* already converted into maltose and dextrin. Besides its digestive action, saliva aids the sense of taste by dissolving food, since it is impossible to perceive any taste in an insoluble substance.

In infants fed by the bottle, the mouth is often infested by a white parasitic fungus known as "thrush". This is due to unclean feeding, and can easily be removed by a little borax. The popular remedy, honey and borax, is quite useless, as the parasite thrives on the honey, which thus destroys the germicide action of borax. Feeding-bottles and their appliances should be kept scruplously clean, and siphoned out by boiling water immediately after use, and before any milk left in them clogs the tubing. It is a good plan to have two bottles, the unused one filled with borax solution, in hot weather especially.

Under the combined action of the teeth and the various glands, the food, now worked up into a well-lubricated ball, is ready for being propelled into the stomach. The operation

of **swallowing** is divisible into three stages: a voluntary stage, in which the food is carried by the tongue to the back of the mouth; a spasmodic stage, when the food gets just beyond control, marked by the closing of the windpipe; and an involuntary stage, during which the bolus is grasped by the muscles at the back of the throat and shot down the gullet into the stomach, while arrangements are made to keep it from going any other way.

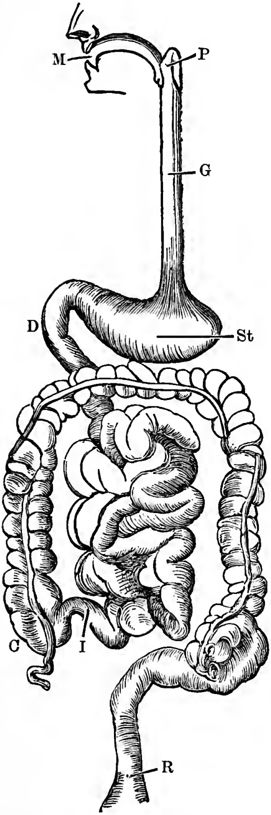


Fig. 6.—Alimentary Canal, including mouth (M), pharynx (P), gullet (G), stomach (St), small (D to I), and large (C to R) intestines.

The gullet, or œsophagus, is nearly 10 inches long, and consists of a muscular tube lined with mucous membrane. It is usually closed, but is dilated in swallowing, and the bolus of food is forced down by muscular action, the passage occupying only about $\frac{1}{10}$ second. After the food has reached the stomach the gullet again closes to prevent its return. That the downward passage of the food is due to muscular action and not to gravity is well seen by watching a horse drinking; the successive mouthfuls of water are seen passing *up* the animal's gullet. Jugglers, also, have no difficulty in swallowing standing on their heads.

SUMMARY.

1. Digestion comprises several processes, mechanical and chemical.

2. Digestion begins in the mouth, by the conversion of starch into dextrin and maltose by the action of saliva.

3. The salivary glands consist of three pairs—parotid, sub-maxillary, and sub-lingual.

4. The active ingredient in saliva is ptyalin, a soluble ferment.

5. Ptyalin is not fully developed in infants before the age of eight months or so.

6. Tea arrests salivary digestion.

7. A tooth consists, as to appearance, of crown, neck, and fang; and as to structure, of enamel, dentine, and cement.

8. The use of the teeth is purely mechanical, but necessary for complete insalivation, and to prepare food for the stomach.

Lesson 12.—GASTRIC DIGESTION.

The **Stomach**, which now receives the food from the gullet, is an oval muscular bag, of the shape shown in the diagram. The thick end lies below the heart, and is hence called the cardiac end (Greek *kardia*, the heart), while the narrow part, extending to the right beyond the middle line, is called the pyloric end, from a valve-like construction fancifully called the pylorus or gate. The organ thus presents a greater and a lesser curvature, the latter uppermost; and owing to contraction of the muscular walls, the food has two kinds of motion. There is a churning motion, whereby the food is rotated along the greater curvature towards the pyloric end, then back along the lesser curvature to the closed gullet opening. At the same time the stomach turns slightly outwards, presenting the greater curvature to the front, and thus causing a feeling of fulness. At intervals, especially towards the end of digestion, a wave-like motion occurs, by which the portion of food already digested is swept towards the pyloric valve, which opens to admit of its passage into the bowel. This is continued till stomach digestion is completed; but if the organ be overworked its stock of energy becomes exhausted, and in that case the sensitiveness of the pyloric valve is lessened, and the valve permits the passage of matters only partly digested.

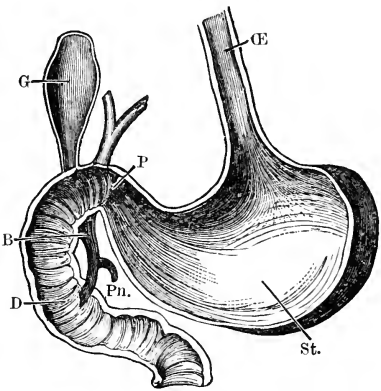


Fig. 7.—The Stomach, &c.

Œ, Gullet; St, stomach; P, pyloric opening; D, duodenum; G, gall-bladder; B, bile-duct; Pn, pancreatic duct.

The interior of an empty stomach shows a number of folds running lengthways, the object being to increase the digestive surface; when the organ is filled with food these creases disappear. The stomach is lined with mucous membrane, containing the very important gastric glands. These secrete the *gastric juice*, and, like the salivary glands, they are excited to activity by the presence of food in the stomach. They are short straight tubes, often arranged in clusters, and are of two kinds—the fundus glands, found in the fundus or cardiac end, and the pyloric glands. The fundus or cardiac glands secrete a gastric juice containing the soluble ferment *pepsin*, as well as free hydrochloric acid; the pyloric secretion contains no acid.

The **Gastric Juice** is thus a very acid liquid, clear, colourless, and having a peculiar odour. It contains very little solid matters, about $\frac{1}{2}$ per cent, and is secreted in considerable quantity, the daily amount being something like one-tenth of the body weight! Besides mucus and salts, it contains free hydrochloric acid and two ferments, pepsin and rennin or rennet. The stomach glands manufacture this hydrochloric acid from chlorides taken in and with food, especially from chloride of sodium or common salt, which is thus necessary to digestion.

Rennet has long been prepared from the stomach of the calf, and is used for curdling milk in cheese-making, since it forms casein; its action in the human stomach is the same. Pepsin acts upon proteid matters, gradually dissolving them in the presence of hydrochloric acid, and converting them first into intermediate bodies called *albumoses*, and finally into *peptone*, which, being very diffusible compared with the original albumen, passes easily into the blood-vessels of the stomach. The action of the stomach may be imitated by the following instructive experiment:—Take three glass beakers, and into each put a little water and some fibrin, obtained by washing a blood-clot. Into No. 1 put a pinch of pepsin, about 3 per 1000 is the proper proportion; into No. 2 a drop or two of hydrochloric acid, 2 per 1000; and into No. 3 both pepsin and acid. Keep these at blood-heat for a quarter of an hour or so, and the following results will be obtained:—

No. 1.	No. 2.	No. 3.
Water + Pepsin and Fibrin.	Water + Acid and Fibrin.	Water + Pepsin + Acid and Fibrin.
No change.	Fibrin swells up and becomes *acid* albumen syntonin.	Fibrin is dissolved, forming peptone.

The gastric digestive process is imitated in making peptonized food, and for this purpose pepsin is supplied in the form of powder or scales, or as "Liquor Pepticus". The important point about gastric digestion is that it takes place in an *acid* medium, and acts almost exclusively on *proteids.* Gastric juice has no action at all on starch or fats, except in so far as it dissolves the cell-walls of the latter, and thus liberates the fat to be acted on in the intestine. Cane-sugar is slowly altered by it into dextrose or grape-sugar, and milk-sugar or lactose is often partly changed into lactic acid by the lactic ferment introduced into the stomach from the air (see page 41). The effects of gastric juice on the several classes of foods may be shown thus:—

Proteids,	...	Coagulated, if not already solid, and changed into albumose, then into peptone.
Fats, ...	...	Liberated by solution of the cell-walls.
Starch,	...	Not affected.
Sugar, ...	...	Partly changed into dextrose, partly into lactic acid.

The whole forms a sourish mass called **Chyme**, and hence gastric digestion is often called chymification. During the process all soluble matters, water, soluble salts, and peptones, are being absorbed by the stomach walls, and the remaining proteids, with all the fats and starches and the great bulk of the sugars, pass through the pyloric valve to be disposed of in the bowel. Contrary to popular estimation, the stomach is not the chief seat of digestive activity, but is to be regarded as merely a preparatory organ, adapting food for treatment in the true digestive chamber, the small intestine. Since the stomach is strongly acid, the action of the alkaline saliva is stopped shortly after the bolus of food enters the stomach, for by the churning which the food undergoes it is soaked through and through with gastric juice. Food remains in the stomach about three hours on an average; some light foods, such as tripe, requiring only one hour's digestion, while smoked ham may take as much as five hours, and lobsters even longer. The results of several experiments have been embodied in the following table (Combe); but there are a good many factors of which the table takes no account, such as the interval since the last meal, state of appetite, amount of work and exercise, method of cooking, and especially quantity of food taken.

Food.	How Cooked.	Time in Stomach.
		Hours.
Aponeurosis, ...	Boiled	3
Apples, sweet and mellow, ...	Raw	1½
Do., sour and mellow, ...	,,	2
Do., sour and hard,	,,	2·50
Apple dumpling,	Boiled	3
Barley, ...	,,	2
Bass, striped, fresh	Broiled	3
Beans, pod, ...	Boiled	2½
Beef, with salt only,	,,	2¾
Do., fresh, lean,	Raw	3
Do., do.,	Fried	4
Do., fresh, dry,	Roasted	3½
Do., with mustard, &c., ...	Boiled	3½
Do., old, hard, salted, ...	,,	4¼
Beef-steak, ...	Broiled	3
Beetroot, ...	Boiled	3¾
Brains, ...	,,	1¾
Bread, corn, ...	Baked	3¼
Do., wheaten, fresh, ...	,,	3½
Butter, ...	Melted	,,
Cabbage, with vinegar, ...	Raw	2
Do., do., ...	Boiled	4½
Do., heads, ...	Raw	2½
Carrot, orange, ...	Boiled	3¼
Cartilage, ...	,,	4¼
Catfish, fresh, ...	Fried	3½
Cheese, old, strong,	Raw	3½
Chicken, full-grown, ...	Fricassee	2¾
Do., soup, ...	Boiled	3
Codfish, cured, dry,	,,	2
Corncake, ...	Baked	2¾
Custard, ...	,,	,,
Duck, domestic,...	Roasted	4
Do., wild ...	,,	4½
Eggs, fresh, whipped, ...	Raw	1½
Do., ...	,,	2
Do., soft-boiled,	Boiled	3
Do., hard-boiled,	,,	3½
Do., ...	Fried	3½
Do., ...	Roasted	2¼
Flounder, fresh,	Fried	3½
Fowl, domestic, ...	Boiled	4
Do., do., ...	Roasted	4
Gelatin, ...	Boiled	2½
Goose, ...	Roasted	,,
Green corn & beans,	Boiled	3¾

Food.	How Cooked.	Time in Stomach.
		Hours.
Hash, meat, and vegetables, ...	Warmed	2½
Heart, ...	Fried	4
Lamb, fresh, ...	Broiled	2½
Liver, fresh ox, ...	,,	2
Milk, ...	Boiled	2
Do., ...	Raw	2¼
Mutton, fresh, ...	Broiled	3
Do., ...	Boiled	3
Do., ...	Roasted	3¼
Oysters, fresh, ...	Raw	2·55
Do., ...	Roasted	3¼
Do., ...	Stewed	3½
Do., soup, ...	Boiled	3½
Parsnips, ...	,,	2½
Pig, sucking, ...	Roasted	,,
Pig's feet, soused,	Boiled	1
Pork, recently salted, ...	,,	4½
Do., ...	Fried	4¼
Do., ...	Raw	3
Do., steaks, ...	Broiled	3¼
Do., ...	Stewed	3
Do., fat or lean,	Roasted	5¼
Potatoes, ...	Baked	2½
Do., ...	Boiled	3½
Do., ...	Roasted	2½
Rice, ...	Boiled	1
Sago, ...	,,	1¾
Salmon, salted, ...	,,	4
Sausage, fresh, ...	Broiled	3·20
Soup, barley, ...	Boiled	1½
Do., beans, ...	,,	3
Do., beef, vegetables, bread,	,,	4
Do., marrow bone,	,,	4½
Do., mutton, ...	,,	3½
Spinal marrow, ...	,,	2·40
Sponge-cake, ...	Baked	2½
Suet, beef, fresh,	Boiled	5·3
Do., mutton, ...	,,	4½
Tapioca, ...	,,	2
Tendon, ...	,,	5½
Tripe, soused, ...	,,	1
Trout, salmon, fresh, ...	,,	1½
Do., do., ...	Fried	,,
Turkey, wild, ...	Roasted	2·18
Do., domestic,...	Boiled	2·25
Do., do., ...	Roasted	2½
Turnips, ...	Boiled	3½
Veal, fresh, ...	Broiled	4
Do., ...	Fried	4½
Venison, steaks,...	Broiled	1·35

At this point some remarks on **Indigestion** may not be out of place. Dyspepsia, or disorder of gastric digestion, may be induced by several causes. It may be due to want of tone in the muscular walls of the stomach, so that the churning and propulsive movements are interfered with; or it may be due to defects in the secretion of gastric juice, a deficiency of pepsin or hydrochloric acid, or perhaps an excessive amount of the latter. But the commonest cause of indigestion is irritation of the mucous lining of the stomach, so that the mucous glands pour out an abundant supply of thick, ropy, alkaline mucus, which completely clogs the openings of the peptic glands and prevents the gastric juice from exercising its full influence on the food. This gastric catarrh is most commonly induced by the introduction into the stomach of unsuitable materials, which act as irritants to the delicate mucous membrane. Imperfect mastication is largely responsible for this, the food being introduced into the stomach in a rough condition instead of the salivated mass intended by nature. Imperfect chewing may occasionally be attributed to defects in the teeth, particularly in the molar teeth, and in such a case the cure of indigestion is a matter more for a dentist than a physician. But by far the most prevalent cause of incomplete mastication is to be found in the high pressure of modern life, and especially city life; the hurry which gives a man twenty minutes for lunch or dinner; the suburban train which lets him home for dinner, but cheats him in the act out of two-thirds of the dinner hour. The stomach expends a certain amount of energy in performing its duties, and requires a corresponding amount of what may be called nerve-force; nature demands, therefore, that the commencement at least of digestion shall be unhampered by calls upon the organism from without in the shape of muscular exercise, mental distraction, or the thousand-and-one worries of commercial or domestic life. No man can serve two masters, and the stomach, which at such a time needs an increased supply of blood, must perforce suffer if that same blood be imperatively demanded for muscle or brain.

Not only does imperfectly chewed food act as an irritant, but any unsuitable food does, even suitable food if in excess; for the gastric-juice is not sufficient to cope with such a quantity, and the result is that the partially-digested mass behaves like a foreign body. A similar result may be due to decomposing foods, the action in their case being chemical as well as mechanical; and the same kind of action is induced by

condiments, mustard, spices, &c., which in small quantities stimulate the gastric glands, but exhaust them when taken in excess. In all cases of indigestion the golden rule is, small quantities eaten slowly. If the gastric glands are clogged with mucus, this obstruction may be washed out by a tea-cupful of hot water shortly before meals; the hot water here serving not only to remove the obstructing mucus, but by its warmth to encourage an increased supply of blood to the stomach. If the pepsin be deficient, then the proteid food taken must be proportionately diminished, and the stomach encouraged to increase the supply; or the deficiency may be made up by peptonizing the food and so saving the stomach unnecessary labour, remembering, however, that artificial pepsin is only a crutch, and that what is wanted is to make the stomach self-supporting. All irritating food should be avoided; even milk, though sufficiently bland, is in many cases objectionable, because it coagulates in the stomach, forming large clots of casein. This may be avoided by peptonizing the milk beforehand, or by taking care that the casein shall be coagulated in a finely-divided form, as happens naturally with human milk. This may be done by adding barley-water, which by its mucilaginous condition prevents the formation of clots, or by lemon juice, or even a few drops of hydrochloric acid, which precipitates the casein as a fine powder. The object aimed at is to give the pepsin of the stomach a large surface to work upon, and so all meat should be taken minced, short-fibred meats being preferred, and bread should be toasted or stale, so as to be readily broken up by the teeth, and to avoid forming large heavy sodden masses. In cases of severe gastric catarrh, when even milk does not agree, the use of whey, or, better still, of butter-milk, will be found of great advantage. A continental stomach specialist gives as his dictum in dyspepsia, "When the patient is thirsty, let him drink butter-milk; when the patient is hungry, let him eat butter-milk".

In dyspepsia and other gastric disorders it is a common practice to give bland starchy foods like arrowroot, but the wisdom of this course is open to question. The stomach does not deal at all with starchy foods, and what is wanted is, not to ignore the stomach, but to train it by slow degrees to perform its proper functions. Starchy matters undergo lactic fermentation, and this is very apt to be followed by butyric fermentation, accompanied by the evolution of carbonic acid gas and hydrogen. These gases disturb the stomach, and

cause it to press upon the heart, causing the pain known as "heartburn", accompanied by eructations of intensely sour fermenting matter, familiarly known as "water-brash".

The stomach naturally contains gases, derived partly from air swallowed, and partly from the intestine. Of the air taken in with food, nearly all the oxygen is absorbed by the blood, being replaced by twice the bulk of carbonic acid gas, so that the latter instead of being only ·04 per cent as in the atmosphere, bulks as largely as from 21 to 33 per cent. In butyric fermentation hydrogen also is produced, ranging from 6 to 27 per cent, and there may be, in addition, hydrocarbons and other gases from the intestine.

SUMMARY.

1. The stomach is a muscular bag, lined with mucous membrane.
2. In the mucous membrane are the gastric glands, secreting gastric juice.
3. Gastric juice contains free hydrochloric acid, and the ferments pepsin and rennin.
4. Rennin curdles milk; pepsin changes proteids into albumoses, and finally into peptones.
5. Water and soluble materials are absorbed by the stomach vessels.
6. All other food-stuffs—fats, starches, sugars, are scarcely affected by the stomach.

Lesson 13.—INTESTINAL DIGESTION.

After leaving the stomach the digesting mass of chyme passes by the pyloric valve into the **small intestine**, a tube about 20 feet long. The first part of this tube, about 10 inches in length, is the *duodenum*, and it forms a sort of horse-shoe, curving backwards and downwards. About the middle of it there enter the duodenum by the same opening two important juices, the bile from the liver and the pancreatic juice from the pancreas or sweetbread. The duodenum is continued without change of structure into the jejunum or upper third of the small intestine, and this again passes into the ileum. Although these parts of the bowel are distinguished by different names, there is no structural distinction between them. The whole intestinal canal in man is about nine times the length of the

trunk, and in this respect man occupies a position between the carnivora and the purely herbivorous animals, the tiger and lion having an intestine three times their length, the dog five, while the pig, an omnivorous feeder, has one sixteen times its body length, the horse twelve, the ox twenty, and the goat twenty-six.

Like the stomach, the intestine is a muscular tube lined with mucous membrane plentifully supplied with glands. The inner coat of muscles is circular, the outer runs lengthways (fig. 9. *d*, *e*), and by means of these the intestine is capable of a wave-like motion not unlike that shown by a worm crawling along the ground. By means of this slow forward motion, termed *peristalsis*, the contents of the bowel are slowly forced down at the rate of rather less than half an inch per minute, the total time taken to traverse the small bowel being about three hours. The amount of peristaltic movement, like that of the digestive juices, depends upon the stimulus given by food and by the nature of the blood supply.

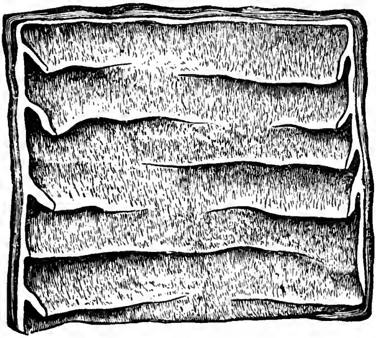


Fig. 8.—Valvulæ Conniventes, exhibited in a portion of jejunum cut open. Two-thirds natural size.

When the blood is highly oxygenated, as before birth or during sleep, there is no stimulus, and consequently no movement; on the other hand, when the stimulus is increased either by excess of carbonic acid gas in the blood or by direct stimulation, peristaltic action is increased, and with a more severe stimulus the muscles become exhausted or even paralysed.

The mucous membrane of the intestine deserves special notice. Unlike that of the stomach, which forms longitudinal creases, the intestinal mucous membrane is thrown into a series of crescentic folds, as shown in the figure, these folds, called *valvulæ conniventes*, serving to increase the digestive and absorptive surface. Further, to attain this end, the interior surface of the intestine is thrown into innumerable finger-like projections called *villi* (Fig. 9, *a*), which dip into the fluid mass of food, and serve mainly as absorbants, by which digested materials find their way into the blood and lymph vessels.

If the bowel of an animal be stroked with the finger under water, the villi give the sensation of touching velvet pile, and in the ox and other animals they may be seen quite easily, though in man they are only from $\frac{1}{50}$ to $\frac{1}{30}$ inch long. Villi are found only in the small intestine, and their number in man has been estimated at 4,000,000.

Closely packed around the villi are the *intestinal glands*, one set consisting of simple tubes, the follicles of Lieberkühn (*b*), and the other, branched and more deeply placed, the glands of Brunner, both supplying *intestinal juice*. Digestion in the small bowel is thus accomplished by these separate juices: bile from the liver, pancreatic juice from the pancreas, and intestinal juice from the glands of the bowel itself; and, as might be expected from this complexity of action and peculiarity of structure, it is in the small intestine that digestion and absorption chiefly take place. Although absorption is very active here, so much fluid is poured into the bowel from these sources that at the end of the small intestine the digesting mass is as fluid as in the duodenum.

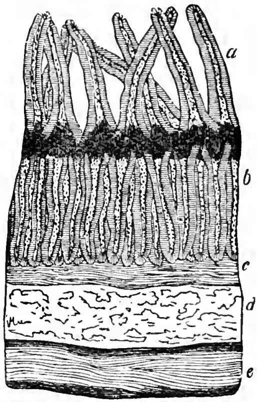


Fig. 9.—Microscopical Structure of the Small Intestine.

When the mucous surface of the bowel is irritated by unsuitable food, these intestinal glands are over-stimulated, and the result is laxity of the bowels, which may pass into **diarrhœa**, and if the irritation be continued, the glands may become exhausted, and the bowels become "dry", causing **constipation**. The same result may be attained by the action of drugs on the nervous system, causing an increased supply of blood to these glands. On the other hand, if the food supplied be liquid or predigested, so as to be quite "bland" or non-irritative, the intestinal glands miss their usual stimulus, less juice is secreted, and constipation follows. Under ordinary circumstances food contains indigestible matter sufficient to induce a moderate flow of intestinal juice, and in this way the bowels are naturally kept open. Diarrhœa is thus due to excess of fluid in the bowel, as constipation is due to defect, and this consideration gives a clue to the dietetic treatment of

these disorders. It is usual to begin treating a case of diarrhœa with a dose of castor-oil or other purgative, although to cure diarrhœa by purging sounds like a contradiction in terms. The oil sweeps out of the bowel any irritating matters which have been exciting the mucous glands, and when that is accomplished, the treatment is continued by giving the patient food as bland as possible.

As in the rest of the digestive canal, the internal or mucous layer is succeeded by submucous and muscular coats, and the outer wall of the bowel is furnished by peritoneum, that membrane which enwraps all the contents of the abdomen. This last is also furnished with glands which keep the surface moist, and enable the coils of intestine to slip freely upon each other during digestion.

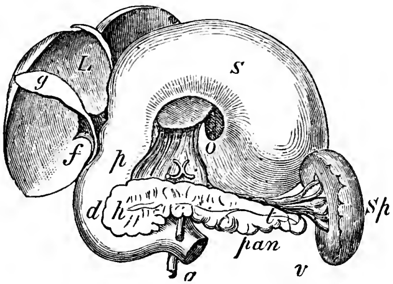


Fig. 10.—Relations of the Stomach to the Liver, Pancreas, and Spleen.

Besides intestinal juice, supplied by the bowel glands all along the intestine, there are poured into the duodenum other two important fluids, bile and pancreatic juice. The latter is secreted by the **pancreas** or sweetbread, a compound tubular gland, in structure not unlike a salivary gland, and indeed called in Germany the abdominal salivary gland. It extends from left to right behind and below the stomach, and it tapers in the opposite direction, the broad end or exit fitting into the curve of the duodenum. The **Pancreatic Juice** finds its way into the duodenum by the same opening as that which conveys the bile. It is a clear fluid, somewhat thickish, without colour or smell, but having a saltish taste and *alkaline* reaction. It is poured into the bowel in greatest quantity about two or three hours after a meal, *i.e.* about the time when gastric digestion is at an end.

Pancreatic juice contains several important ferments:—1. *amylopsin*, a ferment resembling the ptyalin of saliva, and like it converting starch into sugar; 2. *trypsin*, a ferment like pepsin, capable of converting proteids into peptones; 3. a *milk-curdling* ferment like rennet; 4. *steapsin*, a substance capable of decomposing fats into fatty acids and glycerine, and so forming

soaps; 5. possibly another ferment producing an *emulsion* with fats or oils, *i.e.* reducing them to oil globules so exceedingly small that they have no difficulty in passing through the intestinal wall into the interior of the villi, and so into the lymph channels.

It will thus be seen that pancreatic juice is a much more potent digestive agent than gastric juice, inasmuch as it is able to deal with all classes of goods, whereas the latter acts solely upon proteids. Another difference consists in the fact that pancreatic juice acts in an *alkaline* medium, and is itself strongly alkaline, while pepsin acts in an *acid* medium. Hence, when chyme enters the bowels from the stomach, the pepsin is neutralized and its action arrested, just as salivary action is arrested in the stomach.

The **digestion of carbohydrates**, which had been begun by the saliva, but had gone but a little way, is now continued by the ferment amylopsin, and the whole of the starchy materials of the food are now converted into maltose, sugar of malt. The action is further continued by the intestinal juice, and the maltose thus formed is converted into dextrose or grape-sugar, in which condition it finds its way into the blood. The latter juice also acts upon cane-sugar, inverting it, and producing dextrose and levulose, a mixture of glucoses.

Proteids are acted upon by the trypsin of the pancreatic juice, and are converted into albumoses and peptones, but in this case part of the peptone produced is further transformed into other substances, such as leucin and tyrosin, which again in the large intestine undergo putrefaction, forming indol, skatol, and various gases. The intestinal juice contains a similar proteolytic ferment.

Both pepsin and trypsin are now prepared from animals, and are extensively used for peptonizing foods to aid the feeble of digestion; for it is clear that if the proteid matter of food is peptonized a stage is saved in digestion just as in feeding with malt or sugar instead of starch. Since trypsin acts in an alkaline medium a little baking-soda is generally added along with pancreatic extract, the mixture is kept at blood heat for about two hours, then boiled for a few minutes to arrest any further action of the ferment. Foods peptonized in this way are more palatable than those prepared by pepsin, as the latter imparts a bitter taste and an unpleasant smell. Pancreatic extract is now sold either as peptonizing powders or in the liquid form, "Liquor Pancreaticus". Since trypsin

is destroyed by the acid contents of the stomach, it is useless to give pancreatic extract along with food; it must either be administered by the bowel, or else protected from the action of the gastric juice by being enclosed in capsules of keratin, a substance unaffected by acids, but soluble in alkalies, thus liberating the contents of the capsule at the proper place.

In considering the processes in the intestine it may be proper here to enumerate the functions of **Bile**, reserving the structure of the liver for further treatment. Bile, although an excretion, *i.e.* a waste product, plays an important part in digestion and absorption, especially of fat. It is a bronze-coloured liquid, bitter, slightly sticky owing to mucus, and neutral in reaction, though containing in combination with soda two acids known as the bile-acids. It is a powerful solvent of fats and oils, and, indeed, ox-gall is one of the strongest soaps known. In the absorption of fat, bile assists in emulsifying neutral fats, and at the same time it moistens the intestinal wall, so that the minute globules can be absorbed with perfect ease. In dogs, when the bile was not allowed to enter the bowel, it was found that only two-fifths of the fat in the food was absorbed, the rest being excreted as waste, whereas in ordinary digestion almost all the fat was absorbed. Besides its chemical action, bile moistens the bowel wall and keeps the contents of the bowel fluid, thus acting as a natural purgative. It seems to have an antiseptic action within the body, arresting putrefaction, and hence in liver disorders, such as jaundice, the stools become hard, clay-coloured, and offensive.

SUMMARY.

1. The small intestine is a muscular tube, 20 feet long, lined with mucous membrane.

2. It is characterized by valvulæ conniventes and villi, projections of the mucous membrane.

3. By muscular contractions peristalsis is produced, in intensity depending upon the contents of the intestine and the nature of the blood supplied.

4. The digestive juices in the intestine are: 1, intestinal juice; 2, pancreatic juice; 3, bile.

5. Excess of fluid in the intestine produces diarrhœa; defect, constipation.

6. Pancreatic juice contains ferments capable of acting on all classes of foods.

7. Intestinal juice inverts sugar and also acts on proteids.

8. Bile assists in saponifying and emulsifying fats, besides stimulating the bowel and arresting putrefaction.

9. By intestinal digestion proteids are converted into peptones and other products, starches into dextrose, sugars also into dextrose, and fats into emulsions and soaps.

LESSON 14.—THE LARGE INTESTINE.

When food has been in the small intestine for about three hours it passes into the **Large Intestine** or colon. At the place where the ileum enters the colon the walls of the former are prolonged so as to form a two-lipped fold or valve, the ileo-colic valve, so arranged as to permit a passage towards the colon, but not in the reverse direction. The large intestine is about five feet in length, and forms three sides of a square, enclosing as in a frame the small intestine. The latter enters it on the right side, but not at the extremity, there being a blind end called the cæcum, to which is attached a worm-like spiral tube, the vermiform appendix. The cæcum passes into the colon proper, ascending to the liver, then crossing below the stomach, so as to envelop the pancreas, and descending on the left side to form the S-shaped bend called the sigmoid flexure. This again is

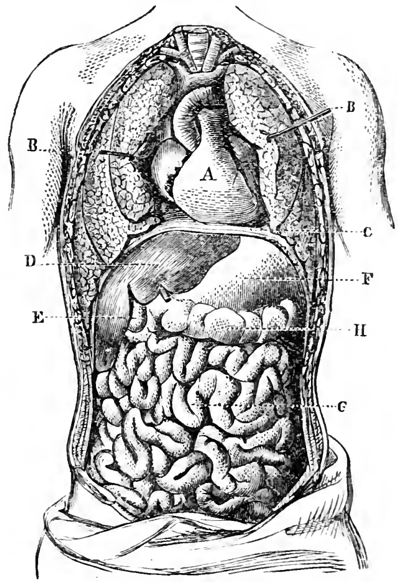


Fig. 11.—The Contents of Chest and Abdomen shown in their Positions.

A, Heart; B, B, lungs; C, diaphragm, and a horizontal partition between chest and belly; D, liver; E, gall-bladder; F, stomach; G, coils of small intestine; H, transverse part of large intestine.

succeeded by the rectum, in which the waste materials of digestion are received until they can be expelled from the body. The residue or fæces amounts to about five ounces per day, but the amount varies with the nature of the food taken, being small after a flesh diet, and large if the amount of indigestible material is great, as in vegetable feeding.

The large intestine has a structure like that of the small bowel, having an outer serous coat of peritoneum, two muscular coats, the outer longitudinal and the inner circular, a submucous layer, and innermost the mucous layer. The outer muscles, instead of forming a continuous sheet, as in the small intestine, are in the cæcum and colon confined to three bands, which give those parts a puckered appearance, the bowel being pouched or "gathered", as if the bands of muscles were too short for its length. Villi and valvulæ conniventes are no longer found in the mucous membrane, but glands and lymph follicles are still found.

The large intestine retains its contents for about twelve hours, and all that time absorption of the more liquid portion proceeds rapidly, the residue becoming harder and drier. As might be supposed from the presence of the ileo-colic valve, the processes in the large intestine are sharply marked off from those in the upper part of the digestive tract, and in general the changes may be summed up in the phrase "**putrefactive fermentation**", due to organized ferments. These last, as distinguished from ptyalin-pepsin and other "soluble" ferments, are minute fungi, and are known by the various names of bacteria, bacilli, cocci, and so on. They are introduced from without, chiefly in food, since they are not found in the intestine before birth, and hence there are no gases developed in the bowel till then. A familiar example, and one which occurs also in the stomach, is the *lactic-acid* fermentation, as shown in the souring of milk. In this case the exciting cause is the lactic-acid bacillus, which decomposes milk-sugar, and forms it first into grape-sugar, which is then decomposed into lactic acid. This change invariably takes place in the stomach, and very often it is succeeded by the action of another bacillus, the *butyric-acid* bacillus, which decomposes any lactic acid formed, converting it into butyric acid and evolving carbonic acid gas and hydrogen. It is these gases which are so troublesome in indigestion owing to the stomach dilation produced, and the feeling of "heartburn" already referred to.

Another fermentation with which we are familiar outside the

body is the *alcoholic* fermentation, produced by several kinds of yeast. In this the starches and sugars of the food, already changed into dextrose, are further decomposed into alcohol, with evolution of carbonic acid gas. This fermentation does not occur in the body, unless owing to the presence of yeast in the intestines.

The ferment *invertin* occurs in intestinal juice, and is supposed to be a product of other fungi introduced from without; it forms sucroses into "invert-sugar".

Man possesses little power of digesting cellulose or vegetable tissue, although its chemical composition is identical with that of starch. This power, however, is possessed in a high degree by herbivora, such as the ox, and they manage to digest half the cellulose eaten. This is accomplished by putrefactive fermentation, and to ensure this the digestive process is modified by the existence of a paunch or preliminary stomach, into which the half-chewed materials, well moistened with saliva, are introduced, there to putrefy and become converted into sugary matters before being returned to the mouth for final salivation in the process of "chewing the cud".

Fats are also acted upon by various organisms, becoming decomposed into their respective fatty acids and glycerin, and these again are decomposed still further, giving off carbonic acid gas, hydrogen, and marsh-gas.

Proteids, as far as they have escaped the action of the gastric and pancreatic juices, appear to be attacked by ferments

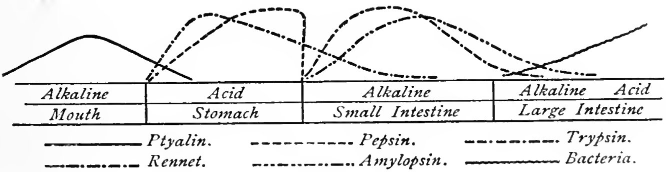


Fig. 12.

existing in the intestine, which are capable of peptonizing them; and in all cases part of the peptone produced by pancreatic digestion is further decomposed into various putrefactive bodies. The leucin formed under the action of the pancreatic juice is further decomposed, yielding ammonia, carbonic acid, and hydrogen, while the tyrosin yields indol and skatol, substances always found in the fæces along with phenol or carbolic acid, especially when absorption of fæces has been

slow. So great is the amount of activity in the lower part of the large intestine that the reaction of its contents, instead of being strongly alkaline, may become acid through the great development of acids formed in putrefaction.

The action of the several **digestive ferments** may be shown graphically in the diagram on preceding page.

SUMMARY OF THE DIGESTIVE FERMENTS.

Fluid.	Ferment.	Action.
Saliva, ...	Ptyalin, ...	Turning starch into maltose.
Gastric Juice, ...	Rennin, ...	Milk curdling.
	Pepsin, ...	Turning proteids into peptones.
	Invertin, ...	Turning cane-sugar into glucose.
Pancreatic Juice,	Amylopsin,	Like ptyalin.
	Trypsin, ...	Like pepsin in alkaline medium.
	Pialyn or Steapsin,	Decomposing fats.
	? ...	Milk curdling.
Intestinal Juice, ...	Invertin, ...	Inverting sucrose.
	Proteolytic,	Like pepsin and trypsin.
Bile, ...	Diastatic, ...	Like ptyalin.

SUMMARY.

1. The large intestine is about five or six feet long, and three inches wide.
2. It has neither villi nor valvulæ conniventes.
3. Its entrance is guarded by the ileo-colic valve, and it terminates in the rectum.
4. The process in the large intestine is chiefly putrefactive fermentation, carried on chiefly by bacteria.
5. By putrefaction, fats and proteids are further decomposed into simpler compounds, but even the fæces contain oxidizable matters.
6. About 5 ozs. of fæces are excreted per day.

Lesson 15.—ABSORPTION.

Since food materials have to be turned into blood in order to reach the tissues, the whole process of digestion aims at rendering those materials soluble and diffusible. Water and salts soluble in it, sugar and the like, are already in the liquid

form in the stomach, and, as has been seen, starchy foods are converted into dextrose, a soluble sugar, leaving only the fats to be considered. These are disposed of in two ways, being partly emulsified, partly made into soluble soaps. In lesson 6 it was pointed out that fat consists of fatty acids and glycerin, and may be split into these two substances by the action of superheated steam. Within the body this same result is brought about by the fat-splitting ferment steapsin found in pancreatic juice. The glycerin and fatty acids are dissolved as such by the fluids of the intestine with the assistance of the bile, and are absorbed by the columnar cells of the bowel lining, but in this act they are again combined to form neutral fats, which accordingly appear as oil globules within the columnar cells of the villi. A good deal of the fat, however, is not split as above, but is made into soluble soaps by combination with soda from the bile, according to the scheme given on p. 33. These soaps with the glycerin set free in this process are absorbed by the columnar cells, in which the process is reversed so as to form neutral fats once more. These two processes give rise to the **solution** and **emulsion** theories of fat absorption. A very good example of an **emulsion** is supplied by milk, which, when examined under the microscope, is seen to consist of very minute globules of oil swimming in a clear fluid. These globules are exceedingly small, from $\frac{3}{50000}$ to $\frac{10}{50000}$ inch in diameter, but even the finest of them is large compared with the globules found in the emulsion of the intestine.

It now remains to consider the **physical forces** concerned in the passage of these fluid and emulsified materials from the intestine into the blood, these being **diffusion** and filtration. When gas escapes at one corner of a room, the smell of the gas pervades the whole room, because coal-gas, though lighter than air, tends to diffuse rapidly through air instead of rising to the ceiling; and it is found that gases behave according to Graham's law, viz.: velocity of diffusion is inversely proportional to the square root of the density. Diffusion of gases will come before us again in connection with respiration.

If alcohol be slowly poured upon water, in spite of the fact that it is lighter than water, it will gradually tend to diffuse downwards, and the liquids will mix at their line of junction. If the liquids be separated by a porous partition, diffusion will still take place through the partition; alcohol will pass to the water, and water to the alcohol, till the liquids on both sides of the partition have the same density. The digestive process

presents many examples of diffusion through porous membrane.

For the porous partition let there now be used a piece of animal membrane, or non-porous parchment paper, such as is used for covering preserves; diffusion currents will again be set up through the membrane, tending to produce average density in the liquids employed. Diffusion through non-porous walls is called **Osmosis**, and the inward and outward currents are distinguished by the terms endosmosis and exosmosis, although there is always a double current. By the arrangement shown in the figure it is easy to measure the rate of diffusion. The vessel *v* has a bottom of animal membrane and is filled with brine, then immersed in another vessel *a b* containing water. As water passes into *v* faster than brine passes out, the contents of *n* will rise in the graduated tube. Such an apparatus is called an endosmometer, and by its means the rates of diffusion or "endosmotic equivalents" of various substances have been determined, among them the following:—

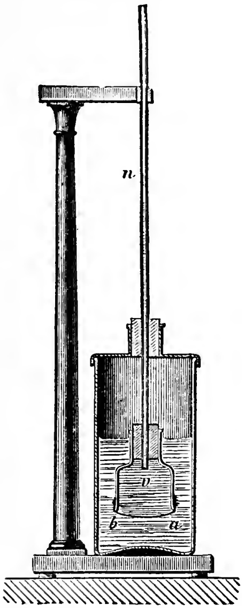


Fig. 13.—Endosmometer.

Potassium bisulphate, ...	2·3	Potassium sulphate,	12·0
Sodium chloride (salt), ...	4·3	Sulphuric acid, ...	0·39
Sugar, ...	7·1	Caustic potash, ...	215·0
Sodium sulphate, ...	11·6	Peptone (2 to 9 °/$_o$),	7 to 10
Magnesium sulphate (Epsom salts),	11·7	Albumen, ...	100

This means that 4·3 parts of water will pass in one direction while one part of salt is passing the other way, and it will be seen that while salts, sugar, and peptone are fairly diffusible, albumen diffuses with great difficulty, no fewer than 100 parts of water passing for every 1 of albumen in the reverse direction. This explains the necessity for its conversion into peptone, and also the fact that the contents of the small intestine are as fluid at the ileo-cæcal valve as in the duodenum.

If brine be heated so as to expel some of its water, crystals of salt appear, and most solutions yield crystals on evaporating. Starch, glue, and other substances, however, do not form crystals at all, but set into a paste or jelly; these are called **Colloid** or glue-like substances, as distinguished from **Crystalloids** or crystal-formers. Albumen is a colloid substance, and, like the rest of them, diffuses with difficulty, so that the apparatus already mentioned may be used for separating colloids from crystalloids when existing together in solution, for the latter are readily diffusible. This process is called dialysis, and is often used in detecting cases of poisoning. The contents of the stomach are transferred to the dialyser, and then floated on water, when any arsenic, strychnine, or other crystalloid poison diffuses into the water, leaving the colloid contents of the stomach behind. As the above figures show, rate of diffusion depends on the nature of the fluids, acids diffusing most rapidly; it is affected by heat and degree of concentration: hot dilute solutions diffuse easily, concentrated solution not so quickly.

Another physical force concerned in absorption is capillary attraction, which is well seen by the action of loaf-sugar upon tea. This is concerned, not so much with digestion, as with assimilation, for the tissues are in this way soaked in lymph. Of greater importance is **Filtration**, through membrane relatively coarsely porous, owing either to pressure from above or suction from beneath. The intestine is a muscular tube, and every time a peristaltic wave passes along the bowel its contents are pressed through the porous walls, especially those of the villi. Of negative filtration, or filtration by suction, an example is supplied by the villi themselves. They, too, have strands of muscle fibre, and when they relax they exercise a sucking action upon the fluid in the bowel.

Absorption may take place wherever a free mucous surface occurs; thus potassium cyanide, although not swallowed, may be absorbed by the mouth. The stomach readily absorbs water, and salts soluble in water, sugars, peptones, most poisons, and alcoholic solutions; and, of course, absorption is most rapid when these are taken into an empty stomach. The peculiar structure of the intestine fits it for being the great seat of digestion and absorption, and in this respect the several parts of the digestive tract may be thus arranged in order of merit: small intestine, large intestine, stomach, mouth, pharynx, gullet.

As has been said, the small intestine is characterized by a great increase of surface owing to its crescentic folds, and still more to the minute projections called villi, which cover the whole surface. The structure of a **Villus** will be understood from the figure. The free surface consists of columnar epithelium cells (fig. 14, *a*) and goblet cells (*e*), similar to the general surface of the bowel; below this, and constituting the body of the villus, is a mass of spongy basket-work or "adenoid" tissue, supplied with blood-vessels (*b*, *c*) and nerves, and containing strands of muscle, by virtue of which the whole villus may contract and relax again. The spaces of this spongy tissue communicate with each other and with a central space or vessel (*d*), called the **Lacteal**, which serves to drain the contents away from the bowel. If the lacteal has any wall at all, it is a very thin one and porous, so as to discharge its chief function, viz. the absorption of emulsified fats. The minute oil-globules of the emulsion are taken up by the vital action of the epithelial cells, passed through the underlying spongy tissue, and so sent on to the lacteal, which conveys them into the lymphatic system. The vital activity of the cells is manifested in another way. We have already seen that albumen is converted into peptone for purposes of diffusion, but in passing through the walls of the alimentary canal into the blood-vessels beneath, this peptone is somehow converted into albumen again, for not a trace of peptone is found in the blood; indeed, if peptone be injected into the blood it has a disturbing influence, and is rapidly excreted by the kidneys, while in large doses it proves fatal. In a similar manner saponified fats seem to reunite with glycerin in the villi, so as to reconstitute neutral fats, for no fatty acids are found free, either in the blood-vessels or the lymphatics of the small intestine. It will be seen later on that the other great class of food-stuffs, the carbohydrates, are treated in a like fashion, the starches which were converted into sugar being reconverted into a kind of starch in the liver.

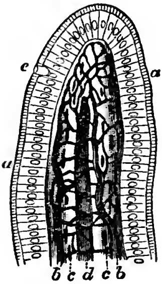


Fig. 14.—A Villus of the Small Intestine, largely magnified.

The processes of absorption from the intestine may be summarized as follows:—

(*a*) *Solutions* are absorbed into both blood-vessels and lacteals.

1. Water and soluble salts, into the blood-vessels chiefly.

2. Sugars, more slowly, mostly into blood-vessels.

3. Peptones, into blood-vessels, changed in passing into albumen.

4. Unchanged proteids diffuse with great difficulty, and in this case the vital activity of the epithelial cells comes into play.

5. Soluble soaps, representing a small part of the fatty food, into blood-vessels and lacteals, changed into fats again.

6. Neutral fats, into the lacteals.

(*b*) *Oil-globules*, into the lacteals.

Roughly speaking, *fats alone* pass into the lacteals to join the lymphatic system; *all other food-stuffs* pass into the blood-vessels, and are carried by the portal vein to the liver for further treatment.

The bearing of all this upon nutrient enemata is obvious. Since the small intestine is the chief seat of absorption, it is desirable in administering an enema to encourage the contents to pass the ileo-colic valve, so as to enter the small intestine; and in order to effect this the enema should be just about blood-heat, so as not to stimulate the bowel wall and set up peristalsis; and it should be administered slowly to the patient in the recumbent position or on the left side, so that its passage from colon to small intestine may be facilitated as much as possible. About one-fourth of proteid matter thus injected can be absorbed.

SUMMARY.

1. To pass into the blood food must be rendered soluble and diffusible.

2. The forces in diffusion are partly mechanical—capillary attraction, filtration under pressure, osmosis; partly vital.

3. By their vital action the cells of the bowel wall absorb oil-globules, and reconvert peptones and soaps into albumen and fats respectively.

4. Diffusible matters leave the bowel by two different routes: by the blood-vessels and so to the liver, or by the lacteals into the lymphatic system.

5. Fats alone go by the lacteals; all other foods by the blood vessels.

6. The small intestine is the great seat of absorptive activity, next to it the large intestine, then the stomach.

Lesson 16.—THE LYMPHATIC SYSTEM.

The tissues of the body receive their supplies of nutriment from the blood-vessels, which allow the more fluid portions of the blood to exude into the neighbourhood of the tissues. This fluid, which fills up all the little spaces between the tissues, and bathes the tissues themselves, is **Lymph**, and it acts as a go-between for these and the blood; certain consti-

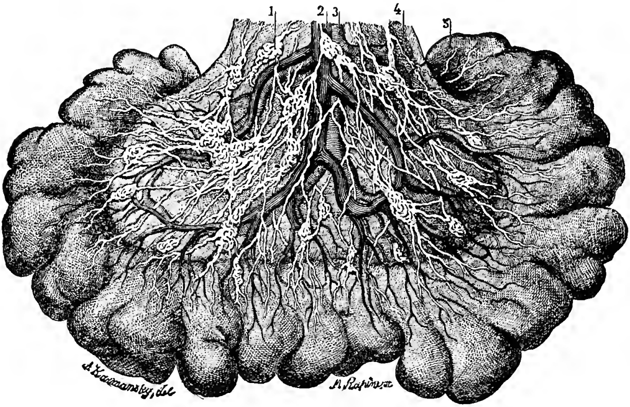


Fig. 15.—Mesenteric Glands.

4 points to the membrane of the mesentery from which the bowel (5), seen in folds, is suspended. 1 points to a gland, a large number of which is present, connected to one another and to the bowel by fine lymphatic vessels. 2 indicates a vein, and 3 an artery ramifying through the mesentery and over the bowel.

tuents of the blood pass into the lymph, are in turn assimilated by the tissues, while these again return some matters into the lymph stream and others directly into the blood. All tissues are not equally active, nor is any one equally active at all times; the gastric glands, for example, are not secreting gastric juice to any great extent when the stomach is empty. Since the blood supply is fairly uniform it follows that there will be a great amount of nutrient material unused by the tissues, and this unused material is drained off by special vessels called **Lymphatics**, to be utilized again in the blood-stream. The lymph bathing the tissues may thus be considered as a reservoir of nutriment, fed by one set of supply pipes, the arteries, and drained by two sets, the veins and the lymphatics, the

latter being specially concerned with unused materials and solid particles.

The lymphatics themselves are minute vessels with very thin walls, and they gradually join each other to form large vessels, exactly as veins do. Like veins, they are provided with valves to prevent a backward flow of their contents, and these valves are so numerous as to give a lymphatic vessel when filled the appearance of a string of beads. On their way to join the blood-stream they pass through little oval or roundish bodies about the size of a pea or upwards, called the Lymphatic Glands. These consist of basket-work tissue, entangling little spherical bodies, the lymph corpuscles; and as the lymph-stream flows through the spongy mass of the gland it washes away some of these corpuscles, and also acquires the property of clotting, thus beginning to assume the characters of blood. Lymphatic glands are pretty numerous at the groin, shoulder, and neck, and they are found in great numbers on the mesentery, the membrane which supports and enwraps the intestines. One of their functions seems to be the arrest of injurious foreign matters; thus when a slight blood-poisoning occurs, as the result say of an ingrowing toe-nail, any injurious matter introduced by the wound makes itself felt at the lymphatic glands of the groin. In the same way, when a sailor tattoos his hand, some of the colouring matter is carried off by the lymphatics and arrested by the glands at the elbow or the shoulder.

To the lymphatics of the intestine the special name of lacteals has been given, not from any difference of structure, but because of the nature of their contents after a meal, and on account of their greater absorptive activity. Ordinary lymph is a clear, colourless, alkaline fluid, of an albuminous nature, with swimming in it the round bodies already described as lymph corpuscles. Except in colour it resembles the liquid part of blood, and like the latter is capable of clotting. In the intervals of digestion the lacteals contain ordinary lymph, but during digestion, owing to the great amount of emulsified fat taken up by the lacteals, their contents become milky from the presence of oil-globules, and are then called *Chyle*. Chyle is thus found only in the lacteals, *i.e.* the lymphatics of the bowel, and even there only after meals, and it differs from lymph and the fluid portion of blood in containing 1 per cent of fat in the form of oil-globules.

The chyle, carrying the bulk of the fatty foods in an emulsi-

fied condition, passes through the lacteals and the mesenteric

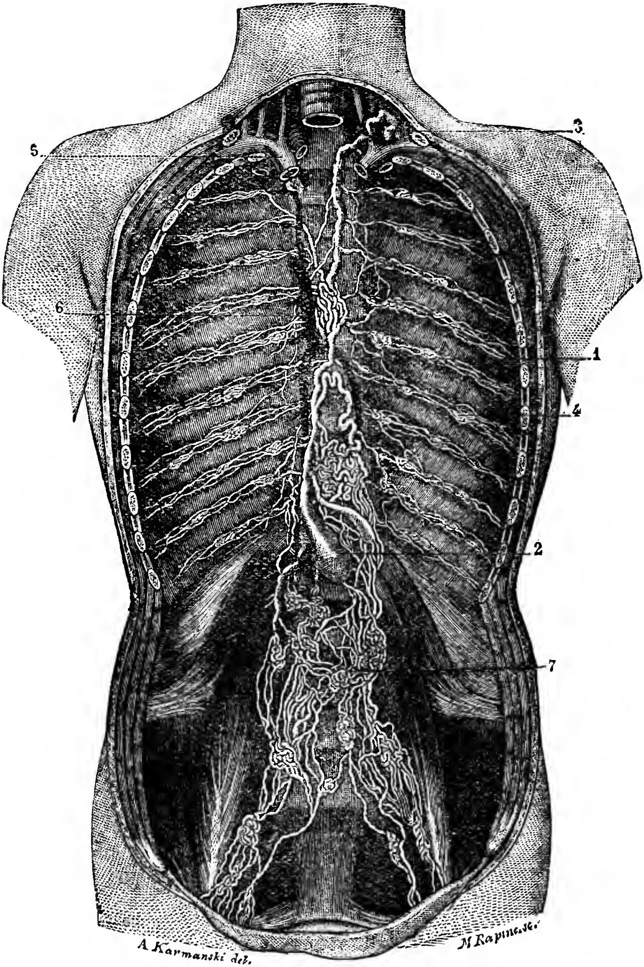


Fig. 16.—The Thoracic Duct and Lymphatic Vessels.

glands into a fairly large tube, the receptacle of the chyle (fig. 16, 2) lying against the backbone at the very back of the

body cavity. From this it proceeds by a narrower tube, about as thick as a slate-pencil, up the chest or thorax, whence it gets the name of Thoracic Duct (1); then the lymph reaches the neck, where it enters the blood-stream at the fork (3) made by the large veins on the left from the head and shoulder. The lymphatics of the right side and the upper part of the body pour their contents into the corresponding fork on the right.

Fatty foods have thus the following history:—They are not digested till they reach the small intestine, when under the combined action of the pancreatic juice and the bile they are

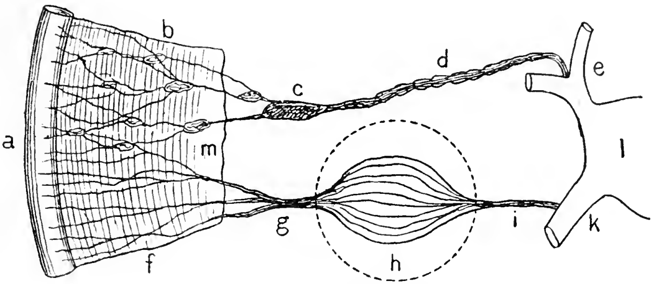


Fig. 17.—Scheme of Intestinal Absorption.

a, Small intestine; b, lacteals and mesenteric glands; c, receptacle of the chyle; d, thoracic duct; e, superior vena cava; f, veins of intestine; g, portal vein; h, liver; i, hepatic veins; k, inferior vena cava; l, right auricle of heart; m, mesentery.

partly saponified but chiefly emulsified. In the act of passing through the bowel wall the soaps thus formed are re-formed into oil, so that all the fat passes into the lacteals as an emulsion, giving rise to the milky fluid called chyle. This passes through the mesenteric glands, receiving lymph-corpuscles *en route*; is then collected in the receptacle of the chyle, and finally creeps up the back of the chest in the thoracic duct to be poured into the blood-stream where the left jugular vein joins the vein of the left shoulder.

On pp. 76, 77 it was noted that other food-stuffs are absorbed into the veins of the digestive tract as water, salts, sugar, and albumens, and it now remains to trace their history. The veins of the stomach and intestines, including those from the spleen, unite into one short trunk called the **Portal Vein**, which, instead of proceeding direct to the heart as most veins do, enters the liver and there divides into smaller and smaller vessels, thus forming a capillary network at either end of its

course. This portal circulation is found in all vertebrate animals, and owing to it the liver is placed in the vantage position of being able to intercept all food materials supplied to the blood, with the single exception of fats, which reach the blood as chyle *via* the lacteals and thoracic ducts.

SUMMARY.

1. Nutriment reaches the tissues as lymph from the blood-vessels.
2. Unused lymph is drained off by special vessels called lymphatics.
3. Lacteals are the lymphatics of the intestine, and their contents are milky only after meals, owing to the presence of fat emulsions.
4. Fats are digested in the intestine, leave it by the lacteals, and enter the blood by the thoracic duct.
5. Other foods leave the digestive tract by the blood-vessels, and are conveyed by the portal vein to the liver for further treatment.

LESSON 17.—THE LIVER AND BILE.

The **Liver** is the heaviest organ in the body, weighing from 50 to 60 ozs., or about $\frac{1}{40}$ of the body-weight. It lies on the right side below the diaphragm, to which it is attached along its upper surface, and it partly overlaps the stomach. The upper surface of the liver is smooth and even, but the lower presents several features. Prominent among these is the *gall-bladder* (see fig. 10), a pear-shaped reservoir for bile when that fluid is not required for digestive purposes.

Entering the liver from below we distinguish the *portal vein*, conveying blood from the whole digestive tract; the *hepatic artery*, carrying pure blood to the liver itself; and the *hepatic veins*, carrying blood from the liver to the great venous trunk which conveys it to the heart. From the two main lobes into which the liver is divided there come the right and left *hepatic ducts* conveying bile, and these are joined by the *cystic duct* from the gall-bladder, thus forming the common bile-duct which enters the bowel at the duodenum. The liver thus receives blood from two different sources—arterial blood from the heart by the hepatic artery, and venous blood from the stomach, intestines, and spleen by the portal vein. Out of these materials it manufactures bile, which is excreted, and

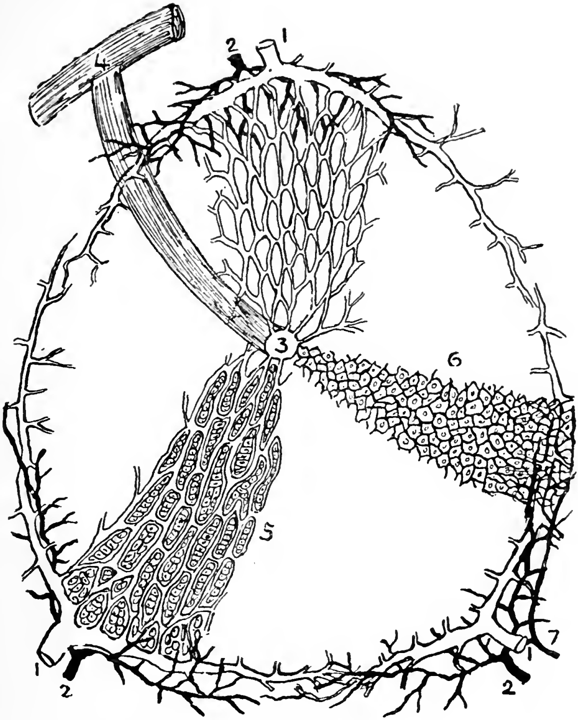


Fig. 18.—Structure of a Liver Lobule.

1. Interlobular branches of portal vein.
2. Branches of hepatic artery.
3. Intralobular vein, draining into
4. Sublobular vein.
5. Liver cells cut lengthways.
6. Cells cut across, showing bile capillaries.
7. Bile-duct.

glycogen, stored up for further treatment, and it finally passes the blood on to the heart by the hepatic vein.

The liver consists of two large lobes, but even by the naked eye these can be resolved into small **lobules**, about the size of a pin-head; and as each lobule may be looked upon as a liver in miniature, we shall get a clear idea of the structure and functions of that organ by studying a single lobule. When the blood-vessels supplying the liver are injected with some colouring material, say Berlin blue in the portal vein and carmine in the hepatic artery, the lobule is seen to present a radiated appearance when cut. Fairly large capillary branches of the portal vein and hepatic artery lie on the outside, in the connective tissue between the lobules, the branches of the former being called *inter-lobular* veins (Lat. *inter*, between); while numerous capillaries pass from these like spokes of a wheel into the centre of the lobule, collecting there into a single vessel, the *intra-lobular* vein (Lat. *intra,* within). This latter is a branch of the hepatic vein, which conveys blood from the liver, so that there is in each lobule a sort of centripetal circulation, blood coming to the liver finding its way to the outside of the lobules, then passing to the centre into an intra-lobular vein, and draining off to the heart by the hepatic vein.

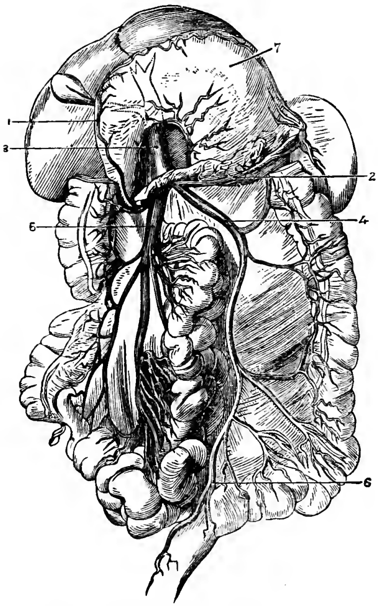


Fig. 19.—The Portal Vein and its Tributaries.

1, Vein from stomach and duodenum; 2, splenic vein; 3, portal vein; 4, inferior mesenteric vein; 5, superior mesenteric vein; 6, superior hæmorrhoidal vein; 7, stomach turned back.

Lying lengthways between the spoke-like capillaries, the microscope reveals the **liver-cells** which constitute the active parts of that organ, little elongated bodies $\frac{1}{1000}$ inch in diameter. These secrete bile and glycogen, store up the latter

within themselves, where it may be seen as grains, while the bile is drained off to the outside of the lobule by a series of excessively fine vessels, the bile capillaries, only $\frac{1}{25000}$ inch in diameter. Thus in the connective tissue which bounds each lobule there run side by side the portal vein and hepatic artery, conveying blood to the liver, and the hepatic vein and bile-duct, carrying material from the liver. Excess of alcohol induces excessive growth of this connective tissue at the expense of the liver-cells, constituting "gin-drinker's liver".

This, then, is the **portal system**, and it will be seen that its peculiarity consists in this, that the blood passes through two sets of capillary vessels, as shown in the diagram. Hence the blood from the liver, having undergone the greatest amount of chemical change, is the warmest blood in the body.

The **functions of the liver** may be conveniently considered under the two heads of manufacture of bile and of glycogen,

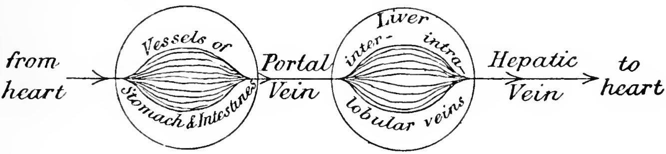


Fig. 20.

though in addition to these it decomposes red corpuscles of the blood-forming urea, and exercises an arrestive action on certain poisons, especially ptomaines, poisons arising from decomposing food or other organic matter.

Bile is a transparent liquid, having a faint smell like musk, is yellowish-brown to dark-green in colour, and intensely bitter. Unlike other digestive juices, it is always being secreted, though chiefly in the daytime, attaining two maxima, 3–5 and 13–15 hours respectively after a meal. When not required for digestion it passes into the gall-bladder, as the usual exit into the bowel is closed; but when food is taken, the increased flow of bile overcomes the resistance here, and the whole is poured into the bowel. That bile is in one sense a waste product is shown by that fact that it is formed before birth, constituting the "meconium" which occupies the bowels.

Of its solids, 13·7 per cent of the whole, the most important are the bile salts, combinations of soda, and the colouring matters bilirubin and biliverdin which give to bile its bronze or green colour. These are formed from the colouring matter

of blood, and are the same substance in different degrees of oxidation; biliverdin (green) occurs in the bile of herbivora, bilirubin (brown) in that of carnivora, but the latter becomes green on exposure. They are further altered in the bowels, and give their characteristic colour to the fæces. Bile also contains a solid alcohol, cholesterin, which often occurs in biliary calculi.

The bile salts are formed within the liver, and they are of importance, since they supply soda for the formation of soaps out of fatty foods, thus aiding the pancreatic juice to digest fats. Ox-gall, which is just hardened bile, is itself one of the best soaps known. The normal course of bile is into the bowels, by which most of its constituents are excreted except the bile salts; these are reabsorbed by the veins of the intestine and find their way back to the liver, thus moving in a circle represented by liver cells—bile capillaries—bile duct—bowels—intestinal veins—portal vein—interlobular veins—liver cells. The compressing action of the diaphragm in ordinary breathing greatly assists the flow of bile, and one can easily see the effect which riding, running, or even walking must have upon the abdominal organs, and especially with reference to the flow not only of bile, but of blood and lymph, of a mass weighing from three to four pounds bounding up and down, as the liver does in riding.

When the flow is obstructed the pressure of bile within the liver may be so great that it is reabsorbed by the lymphatics of the liver, and so gets into the blood, causing **Jaundice**. In such a case the fæces are hard, clayey, offensive, and slowly expelled, showing that bile stimulates the bowel, acting as a natural purgative, and at the same time exercising an antiseptic action, arresting putrefaction. Occasionally, as in sea-sickness, bile gets into the stomach, where it acts as an irritant poison, unless washed out by repeated draughts of hot water, in which it is easily soluble. Bile secretion and bile removal are two very different things, for, as has been seen, some of the materials of bile are reabsorbed in the bowel. The time-honoured blue-pill followed by a seidlitz-powder acts upon this principle, the former stimulating the flow of bile and the latter acting as a purgative, so preventing reabsorption. The chief function of bile is exercised in connection with the digestion of fats; not only does it emulsify neutral fats, and by moistening the pores of the villi assist absorption, but, being itself a neutral substance, it forms a connecting link between

fats and the watery contents of the intestine and lacteals. This was well shown by an experiment on dogs. In the normal condition 99 per cent of the fat eaten was absorbed, but when the bile was allowed to escape without entering the bowel, only 40 per cent was absorbed, the rest appearing in the fæces.

The other function of the liver is clear enough up to a certain point. Just as proteids are peptonized in the alimentary canal, then realbuminized before entering the blood; as fats are partly saponified, then reconverted into neutral fats; so starch and carbohydrates generally are turned into sugar by the digestive juices, only to be reconverted by the liver cells into animal starch, liver starch, or **Glycogen**. This substance can only be obtained from the liver of an animal recently killed, as in a few hours it becomes glucose. Glycogen is found elsewhere in the body, in the muscles, the white corpuscles, and in short wherever there are free developing animal cells; but it is found in greatest quantity in the liver, of which it constitutes 1·2 to 2·6 per cent. It is greatly increased by a diet of carbohydrates, slightly increased by a pure proteid diet, but greatly diminished by a purely fatty diet, while in hunger it disappears altogether.

From these circumstances, Bernard, who discovered glycogen, was led to account for **Glycogenesis** by supposing that the sugar of the blood in the portal vein was converted into starch, in order to prevent the sudden influx of sugar into the blood, which would otherwise follow each meal. There is always a slight amount of sugar in the blood ($\frac{1}{2}$ to 1 per 1000), and as in intervals of digestion the hepatic vein contained more than that, it was assumed that the function of the liver was *to store up carbohydrates* during digestion, allowing the glycogen formed to be reconverted gradually into sugar, thus acting as a regulator of sugar in the blood. Whenever the amount of sugar in the blood exceeds 3 parts per 1000 it appears in the urine, as if there was a temporary diabetes, a disease characterized by the presence of sugar in the urine. Recent researches have confirmed Bernard's view, that in health the blood always contains a small amount of sugar which is consumed in the capillaries, and removed as carbonic acid and water. Diabetes will thus occur when more sugar is added to the organism than can be consumed, or when the sugar consumption in the tissues is interfered with; and there are thus two forms of the disease, a form arising from disturbance of the glycogenic functions of the liver, and a graver form due to disturbance of assimilation

in the tissues. It is suggested that the pancreas assists in the consumption of sugar in the blood by supplying the latter, through the lymph stream, with a sugar-consuming or glycolytic ferment, and pancreatic diabetes is now a well-recognized variety of the graver kind.

SUMMARY.

1. All blood from the intestinal canal, containing soluble food-stuffs, passes through the liver.
2. This blood is collected by the portal vein, which again distributes it to the liver, thus having capillary vessels at either end.
3. The liver receives its own blood-supply by the hepatic artery.
4. Out of portal blood the liver cells manufacture glycogen or liver-starch, and out of all blood they form bile and urea, which are excreted.
5. Bile is thus a waste product, but useful as an auxiliary in digestion.
6. All carbohydrates become glycogen, and are either consumed as such, or possibly stored as fat.

Lesson 18.—BLOOD.

The whole object of digestion has been said to be the transformation of food into a soluble diffusible form, so that by absorption it may become fit for entering the circulation and finally becoming blood. Before describing the mechanism by which this liquid store of energy is carried to the several organs of the body, it will be advisable to examine blood itself.

Looked at superficially, **Blood** is a reddish, thickish fluid, slightly alkaline to the taste, and possessing a peculiar smell. The saying, "Blood is thicker than water", is literally true, for the specific gravity of blood is from 1045 to 1075, water being 1000, and this "thickness" is found to be chiefly due to the presence in it of very minute red bodies called **Red Corpuscles**. So numerous are these that blood behaves like an opaque colour, such as vermilion ground up in water, and when spread on a printed page completely obscures the type. When seen under the microscope these little bodies are found to be biscuit-shaped, hollow in the centre, and almost colour-

less when viewed singly, though reddish in mass (fig. 21, *a*, *b*). In shed blood they show a remarkable tendency to adhere by their flat surfaces, like piles of coppers; but this does not occur in the living blood-vessels. Occasionally there may be seen bodies of another sort—the colourless or **White Corpuscles** (fig. 21, *c*). They are larger, being about $\frac{1}{2500}$ inch in diameter, whereas the red corpuscles are only about $\frac{1}{3300}$ inch. If instead of examining a drop of blood outside the body, it is examined

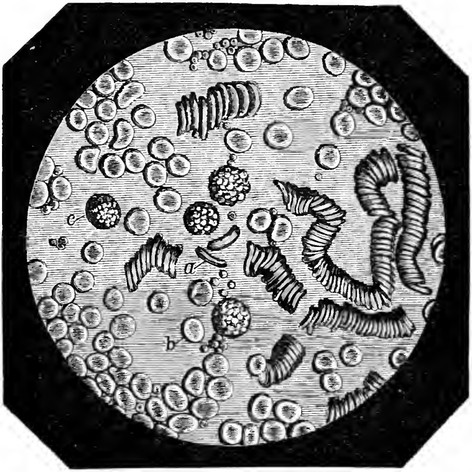


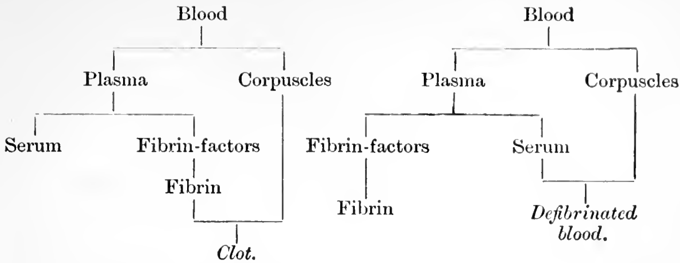
Fig. 21.—A Drop of Blood, seen under a Microscope magnifying by 350 diameters.

in the living state as in a tadpole's tail, the corpuscles may be followed quite easily, since in the frog they are much larger than in man. In a small blood-vessel we see the swiftly-moving mass of red corpuscles keeping in the centre of the stream, exactly as in a street, the corpuscles rolling over one another, sometimes bent, but recovering their shape in virtue of their elasticity, and going where the blood-stream carries them, some into capillary vessels so minute that they have enough to do to squeeze through. But besides these, and in marked contrast to them, there will be observed an occasional white corpuscle, sometimes standing in the very middle of the stream, like a policeman controlling the traffic, more often rolling against the wall of the vessel with slow and deliberate motion, even going back or making its way through the wall alto-

gether into the tissues beyond. In behaviour, and according to a favourite theory, they are the police of the blood.

These solid bodies swim in what seems under the microscope to be a colourless liquid, in reality pale straw-coloured, the liquor of the blood, or blood **Plasma**. About $\frac{1}{3}$ of the weight of the blood consists of corpuscles, and $\frac{2}{3}$ of plasma. It is a watery liquid, containing 90 per cent of water, and 8 to 9 per cent of proteid matters, the various blood-albumens, besides carbonate of potash to which the blood owes its alkalinity, traces of fat, sugar, urea, &c. In fact, when one remembers that blood plasma contains nutriment for every part of the body, the complexity of its composition is at once recognized. The alkalinity of the blood is chiefly due to potassium carbonate (pearl-ash), but in rheumatism and gout the blood becomes acid from lactic and uric acid respectively. It is in preserving the blood alkaline that fruits have their chief use, since the fruit salts, tartrate, citrate, &c., of potash, become converted into carbonates of potash.

The most obvious property of blood is its power of **coagulation**. When the blood of an animal is received into a vessel it sets within a few minutes, forming a jelly, which later on shrinks and squeezes out a pale straw-coloured liquid, not unlike the liquid in a blister; this is **Serum**, and it contains no corpuscles at all. When the clot is examined it is seen to consist of masses of red corpuscles—whence its red colour—entangled in the meshes of an albuminous substance called **Fibrin**. This latter substance does not exist as such in the blood; but when blood is shed, certain substances which were before in solution react upon each other to form solid fibrin, and hence they are called *fibrin-factors*. It will be remembered that coagulation of albumen can be brought about by heat, as when an egg is fried; also, that on the death of an animal its muscle albumen coagulates, causing the "death-stiffening". Coagulation of blood is something similar; certain soluble albuminous matters in presence of air and salts of lime become coagulated and form fibrin. But if freshly-shed blood be stirred up with a bunch of twigs this fibrin is removed as soon as made, and appears on the whisk as a slightly yellowish jelly, and since it has not had time to entangle the corpuscles, those remain in the blood, which thus retains its red colour, but has lost its power of clotting, being now *defibrinated blood.* The annexed scheme will help to give an idea of the formation of clot, and also of defibrinated blood:—



Clotting may be regarded as nature's provision for arresting bleeding. It is accelerated by contact of the blood with foreign bodies, exposure to air, shaking, and hot water—not luke-warm, which encourages bleeding, but as hot as can be borne, in order to coagulate the blood albumens. It is retarded by absence of air, cold, and by adding certain salts to blood; it is prevented entirely if the soluble lime salts of the blood are removed. Several experiments have shown that clotting has nothing to do with the red corpuscles, but with the white corpuscles and the plasma. Three factors at least are needed: fibrinogen, a soluble proteid found in blood-plasma which is capable of becoming solid fibrin; a fibrin-ferment, nucleo-proteid; thirdly, lime salts, which also appear in the plasma. The two latter seem to act in combination, and probably the reason why healthy blood does not clot within the body is that the nucleo-proteid and the lime have not been able to combine. In certain diseased conditions, notably after snake-bite, blood clots within the blood-vessels, thus causing death, and in this case probably nucleo-proteid has been set free by the action of snake-venom on the living cells of the blood and the blood-vessels.

Returning now to the red corpuscles; what are their special duties? A red corpuscle consists of a spongy framework containing a very important substance, **Hæmoglobin**. It is this which gives blood its red colour, and occasionally the hæmoglobin may be dissolved out of the corpuscles, constituting "laky blood". In composition it resembles albumen, consisting of carbon, hydrogen, nitrogen, and oxygen, with the addition of *iron*, and $\frac{9}{10}$ of it is in the shape of hæmatin, which may be regarded as the colouring matter of blood. When the red corpuscles have run their course, and their average life is about 21 to 28 days, the products of their decomposition are carried by the portal vein into the liver, where they are further decomposed. At any rate, out of the waste colouring matter

of blood the liver forms various pigments, the green and bronze bile-pigments, and the colouring matter of the fæces, while the pigment of urine is also due to the same source.

By far their most important function, however, is the **supply of oxygen** to the tissues. Blood itself contains half its bulk of dissolved gases, chiefly carbonic acid gas, but hæmoglobin has the power of combining chemically with oxygen so as to form a loose compound, called oxy-hæmoglobin, of a bright scarlet colour, while hæmoglobin deprived of oxygen, "reduced hæmoglobin", is dark purple. The bearing of this upon respiration is obvious. In order to develop energy, the body, like the steam-engine, requires a combustible substance or fuel in the shape of food, and also a supporter of combustion in the shape of atmospheric oxygen. We have already seen that food products find their way into blood, becoming its plasma, and now the red corpuscles, in virtue of their hæmoglobin, act as oxygen-carriers to the tissues, combining with oxygen in the lungs to form oxy-hæmoglobin, which gives aërated blood its bright scarlet colour, and parting with that oxygen to the tissues, thus giving the blood returning from these a darker shade.

The chemistry of hæmoglobin also explains the action of certain volatile poisons such as coal-gas, sulphuretted hydrogen, prussic acid, &c. In all these the hæmoglobin forms with the poisonous gas a new compound, preventing its union with oxygen in the lungs, so that there is really oxygen-starvation induced, not mechanically by closing the windpipe as in suffocation, but chemically, by the pre-occupation of hæmoglobin in the blood itself. The following will be found a useful summary of the constitution of blood:—

Blood =
- Corpuscles $\frac{1}{3}$
  - Red =
    - Water $\frac{2}{3}$.
    - Solids $\frac{1}{3}$
      - Stroma or framework.
      - Hæmogoblin
        - 90 % Hæmatin.
        - 8 % Proteids.
        - 2 % other matters.
  - White; 1 to 300 or 700 of red.
- Plasma $\frac{2}{3}$
  - Fibrin-factors.
  - Serum
    - $\frac{9}{10}$ Water.
    - $\frac{1}{10}$ Solids
      - Proteids 80 to 90 % = Blood album.
      - Fats, extractives, salts, &c., 20 to 10 %.

The amount of blood in the body is generally reckoned at $\frac{1}{13}$ of the body-weight, and it is distributed roughly as follows:—

$\frac{1}{4}$ in the heart and great vessels; $\frac{1}{4}$ in the skeletal muscles;
$\frac{1}{4}$ in the liver and spleen; $\frac{1}{4}$ in the rest of the body.

SUMMARY.

1. Blood is a fluid tissue, consisting of plasma and corpuscles.
2. The function of plasma is to convey nutriment to the tissues.
3. The function of the red-corpuscles is to convey oxygen to them.
4. This oxygen is conveyed chemically, combined with hæmoglobin, and the degree of oxidation accounts for the varying colour of blood.
5. Hæmoglobin by decomposition in the spleen and liver furnishes most of the pigments of the body.
6. Clotting is due to the formation of fibrin, a solid albumen, by the interaction of various substances in blood-plasma.
7. Serum is plasma deprived of its fibrin-factors.
8. Defibrinated blood is blood deprived of fibrin.

Lesson 19.—THE CIRCULATION.

This fluid tissue, blood, is "laid on" to every part of the body by a closed system of tubes, the blood-vessels, and the difference of pressure necessary to maintain such a circulation is obtained by introducing a force-pump, the heart, into one part of the circuit. In the mechanism of the circulation we distinguish the heart, arteries, capillaries, and veins. **Arteries** are vessels conveying blood *from* the heart, and they usually contain scarlet or oxygenated blood, hence called "arterial" blood; but those conveying blood to the lungs for aëration, convey, as might be expected, impure or "venous" blood; the above definition will meet all cases. They were called "arteries" because after death they are generally found empty, while the veins are gorged with blood. When cut across, an artery exhibits three coats—an outer coat of connective tissue with elastic fibres, to give strength to the vessels; a middle layer of muscular as well as elastic fibres, and an inner layer consisting of an elastic sheath lined by a very thin plating of cells known as endothelium. In virtue of their thick walls and elastic tissue arteries do not collapse when cut, as do the veins, and they are better able to resist pressure or injury. As an artery proceeds on its way from the heart it gives off branches which may join those from other vessels, so that an artery may be tied without apparently affecting very long the supply of blood to the part. Like all tissues, arteries require blood for their

own nourishment, but this is derived not directly from the blood flowing through them, but from smaller vessels arising either in themselves or a neighbouring artery. From a physiological standpoint, the most important coats are the elastic and muscular layers. By reason of the former, arteries yield to the wave generated by the heart-beat, and thus show the phenomena of the *Pulse*, best seen when the artery passes over resisting surface, as at the wrist.

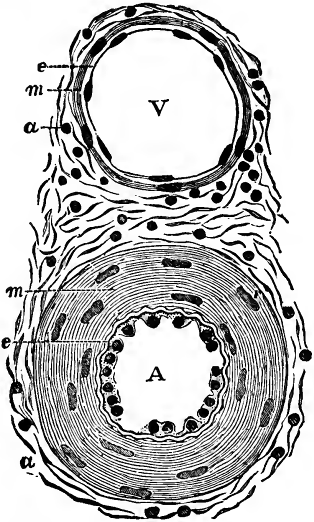


Fig. 22.—Transverse Section through a Small Artery and Vein.

A, Artery; V, vein; *e*, epithelial lining; *m*, middle muscular and elastic coat, thick in the artery, much thinner in the vein; *a*, outer coat of areolar tissue (magnified 350 diameters).

Their muscle fibres are of the involuntary sort, and have a great deal to do with the **regulation of the blood supply.** When they contract, the calibre or bore of the vessel is diminished, so that less blood than usual passes and the part becomes pale. On the other hand, when they are relaxed, as by hot water, the bore of the vessel is increased, more blood flows, and the part in question "blushes". These muscles are not under the control of the will, like those of the limbs, but are controlled by nerve-fibres derived from the sympathetic system, one set tending to contract them and so narrow the vessel, the other set, or vaso-dilators, having the opposite effect. These vaso-motor nerves play a most important part in regulating bodily heat, as will be seen when we come to consider the functions of the skin.

The little branches given off by an artery gradually drop their several coats one by one, till at last there is left nothing but the innermost lining of endothelium. The vessel is now called a **Capillary**, from the Latin *capillus*, a hair, but it must not be supposed that a capillary is nearly so thick as a hair. Some of them are so fine that a single red corpuscle, $\frac{1}{3000}$ inch in diameter, can scarcely make its way through them, while blood in the capillaries may be in contact with the tissues for

only $\frac{1}{100}$ inch or so altogether. It is in the capillaries that interchange of products between blood and tissue takes place; the capillary walls being so thin that gases and liquids easily pass either way. Here the blood parts with its oxygen to the muscles, &c., receiving from them carbonic acid gas, and other "fatigue-products", while the blood-plasma also soaks through the walls and bathes the tissues in lymph, which, as has already been seen, is a sort of reservoir of nutriment, fed by the arteries, and drained off by lymphatics and veins. Since the composition of arterial blood is fairly uniform, and the wants of the tissues almost as varied as their structure, it is obvious that the composition both of lymph and the return-blood in the veins will present important differences in the several cases.

Just as an artery divides and subdivides forming capillaries, so these in turn combine and re-combine into larger and larger vessels called **Veins**, conveying return-blood *to* the heart. Like arteries, veins have three coats, but the elastic and muscular elements are not so much developed, and the walls are thinner, collapsing when cut. They are larger than the corresponding arteries, and are distinguished by the presence of *valves*. These are crescentic folds in the lining of the vein, arranged in pairs so as to permit the passage of blood towards the heart, but filling and consequently closing when from any cause the blood tends to flow back again. They are easily seen in the forearm; if one of the large veins be compressed at the elbow, the veins become gorged with blood, and the valves getting filled become visible as little knots. They are specially numerous in the veins of the leg and arm, where the weight of the blood would tend to produce stagnation in the current. In persons who are much on their feet all day, and whose muscles are not otherwise much worked, the veins of their legs are apt to become flabby and lose their "tone", thus laying a foundation for varicose veins. Whilst a partial remedy may be found in the use of elastic bandages, or even by reclining with the feet higher than the body, the cure for varicose veins is to be sought in restoring tone to the blood-vessels and exercising the muscles of the parts affected. When the relaxing effect of heat upon muscle is remembered, it will be apparent that the common practice of toasting the legs at the fire is largely responsible for this disorder.

The circulation in the veins is maintained by two forces, the "push from behind" of blood from the capillaries, and pressure

from without due chiefly to muscular contraction. The pulse is entirely lost in the capillaries, and so is the direct impetus due to the heart-beat; but, *per contra*, especially in the limbs, muscular action is great, and it is here that the action of valves comes into play. A valve cannot cause a current, it merely controls the direction; but when a muscle contracts in the neighbourhood of a vein, the blood in the latter is compressed, and owing to the valves can flow in only one way, towards the heart. Hence in such places veins are situated among muscles, while arteries are deeply seated; hence also, valves are absent in places beyond the reach of muscular action, such as within the skull, the portal vein, and the large venous trunks conveying blood to the heart from the body generally.

When an artery is cut, the blood is bright scarlet, and flows in jerks owing to the pulse-beat, whereas the blood from a vein is darker in colour, and flows in a steady stream. Capillary bleeding, again, as seen in surface wounds, is an oozing of bright scarlet blood from no definite vessels. Obviously, arterial bleeding is to be stopped by pressure on the side next the heart, venous bleeding by pressure on the further side.

The warmest blood in the body is that which has undergone most chemical change, namely, that from the liver, which has passed through two sets of capillaries; the coldest is that in the superficial veins and the jugular vein, the blood of which is colder even than that returning aërated from the lungs; the purest is that from the kidney, although found in the veins of that organ, a result which is, of course, due to the excretory function of the kidney.

The organ which maintains the circulation is the **Heart**, a twin force-pump, each half provided with collecting chamber and pump, with the necessary valves. Its size is about that of the closed fist, in shape it is roughly conical, and it lies in the chest about the middle line, the base extending across the breast-bone, while the apex touches the chest at the fifth rib. It is held in position solely by the great vessels which proceed from it to the body and lungs, and it is enclosed in a double sac, the pericardium, which invests it loosely. The base of the heart is generally covered with masses of fat, representing the remains of the thymus gland. The appearance and structure of the heart may be studied from a sheep's or bullock's heart. In those the heart is seen to be divisible into two parts. Near the base is a loose chamber with collapsible walls,

Fig. A

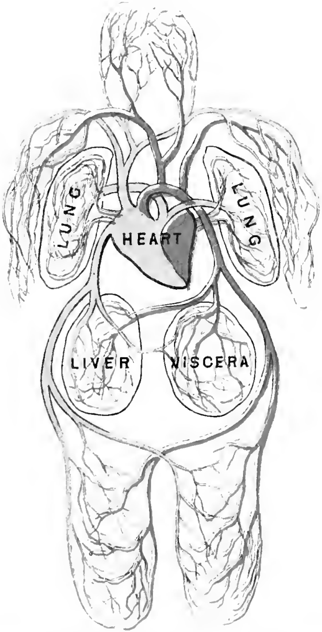
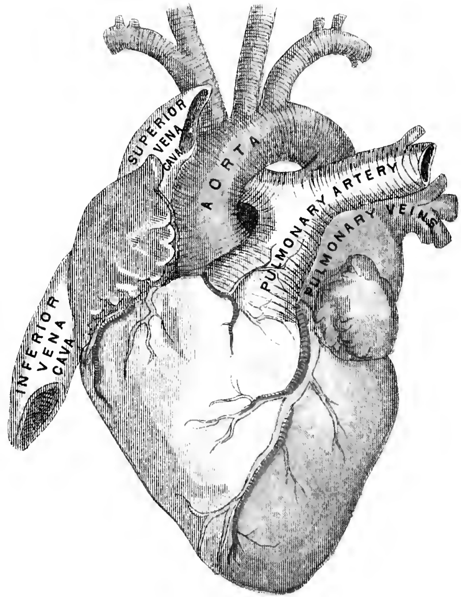


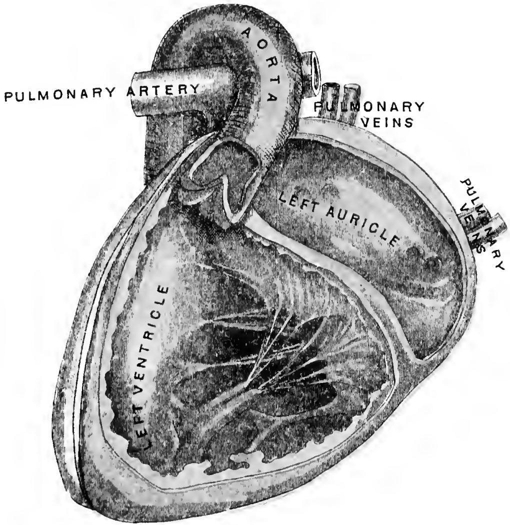
DIAGRAM SHOWING THE CIRCULATION

Fig. B



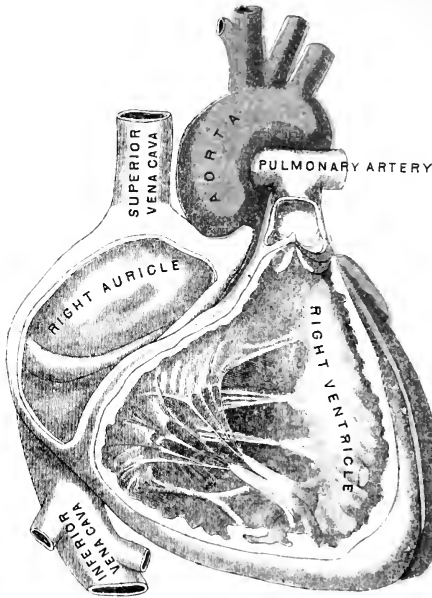
EXTERNAL VIEW OF HEART.

Fig. C



LEFT SECTION OF HEART

Fig. D



RIGHT SECTION OF HEART

easily distinguished by a little flap, fancifully likened to a dog's ear. This is the *Auricle*, or collecting chamber (Latin *aurus*, an ear), and entering it are the two large veins whose business it is to return blood to the heart. The great mass of the heart consists of the pump-chamber or *Ventricle*, into which the auricle leads. See Plate, B, C, D.

While the auricles are generally obscured by fat, the ventricles are free, and are seen to consist of muscular fibres, arranged spirally. On the outside, running from base to apex, there may be seen two grooves containing each an artery and a vein; these are the grooves between the ventricles, and are useful as marking from the outside the boundary between the left and right sides of the heart. In these grooves run the *coronary* vessels, which supply the heart itself with blood, for, like the blood-vessels, the heart is not supported by the blood within it, but has to get its supplies in the usual way. Now, cutting open the heart from auricle to ventricle, the internal structure becomes visible. The ventricles are really muscular bags, and by their contraction they expel the blood from the right ventricle into the lungs to be aërated, and from the left ventricle to the body generally. To prevent the return of the blood to the auricles, valves of connective tissue are provided, attached to a fibrous ring between auricle and ventricle. Between the right auricle and the right ventricle the valve has three flaps, and this is called the *Tricuspid* valve, whereas on the left side there are only two such flaps, giving to the valve its name, the Bicuspid or *Mitral* valve. If the outer edges of these valves were loose they would be driven back altogether by the increasing pressure within the ventricle, but to prevent this they are kept taut by tendinous chords attached to their edges, and inserted, not into the ventricle wall direct, but into small muscles termed papillary muscles. There is thus a compensating action, for, when the ventricles are dilated with blood and beginning to contract, the flaps of the valves are opposed to one another so as to close the opening into the auricle, but as ventricular contraction proceeds the continued approach of the walls would tend to slacken the cords were it not for the fact that the papillary muscles also contract and keep the cords tight, thus holding the edges of the valve together. Of course, if the edges of the valves are eaten away by disease, the natural consequence will be that some blood will get back into the auricle again, thus interfering with the whole circulation.

Since blood cannot return the way it came, owing to the presence of these valves, it has to seek another exit, and this is found at the base of the heart, at the very top of the ventricle, by the *Pulmonary Arteries* carrying blood from the right ventricle to the lungs, and the *Aorta* carrying blood from the left ventricle to the body generally. In man, the blood is thus forced vertically upwards into vessels already filled, and so when the ventricles relax again in the process of filling, the blood in these vessels would fall back into the ventricles. This is prevented by a set of three pouch-like flaps at the mouth of each vessel—the *semi-lunar* valves,—so arranged that the blood, in attempting to fall back, fills the pockets and so brings their edges together with a sharp "click". When you listen carefully to the beating of somebody's heart, two distinct sounds are heard with a short silence between, a dull booming sound followed by a sharper sound, and that again by a longer silence, as in the phrase, "lubb-dúpp — lubb-dúpp". The first sound corresponds to the contraction of the ventricles, but the sharp sound represents the closing of the semi-lunar valves, indicating that the ventricles are beginning to relax or rest.

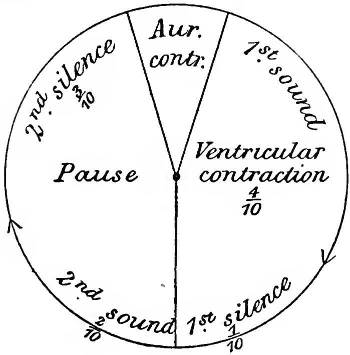


Fig. 23.

The heart is a twin organ, consisting of right and left hearts, each having its own auricle, ventricle, and sets of valves, but the two auricles contract together, expelling blood into the ventricles, then the two ventricles contract together, sending blood into the great arteries, as if a wave of contraction extended along the heart from base to apex. When the ventricles are contracting, the auricles are being filled by the veins, and when they are relaxing they are ready to be refilled by the auricles at the next contraction, for the heart like any other muscle requires intervals of rest, but unlike most muscles, it takes its rest at short intervals, and its action is rhythmic, *i.e.* the various events are repeated in the same order at stated intervals. The annexed diagram exhibits the events of a Cardiac Cycle, as the series is called.

The heart has been compared to a semi-detached cottage, each side having its own rooms, but having no connection with next door; and as the right side of the heart is devoted to impure blood, and the left to aërated blood, any connection between the two would lead to the introduction of mixed blood into the system. Before birth, however, such a connection does exist between the auricles, hence the body of an unborn child is in no place supplied with pure blood.

The blood then pursues the following course through the heart, &c. See Plate, A. Impure blood comes from the body by two large trunks, the superior and inferior venæ cavæ, the former conveying blood from the head and upper part of the body, the latter from the rest of the body, including the portal system. It will be remembered that the thoracic duct pours its contents into the veins of the neck and shoulder, so that the fatty materials of the food have their associates in the small intestine, and reach the heart by a totally different route, *via* lacteals, thoracic duct, and superior vena cava, while sugars, proteids, &c., go by the portal vein, liver, and inferior vena cava. These two trunks converge upon the right auricle, which upon contracting forces the blood through the tricuspid valve into the right ventricle. Since the auricular contraction is not very pronounced, there are no valves at the entrance of the great veins, the head of blood in these being quite sufficient to resist the stroke of the auricle. From the right ventricle the blood is next forced through the semi-lunar valves into the pulmonary arteries, to be conveyed to the lungs for aëration, and it is prevented from returning into the auricle on the one hand or the ventricle on the other by the closing in order of the tricuspid and semi-lunar valves respectively. Since the right ventricle has only to force the blood to the lungs, its walls are only from one-third to half the thickness of the left ventricle, and its weight is just half. The blood thus purified returns from the lungs by the pulmonary veins into the left auricle, from which it passes through the mitral valve into the left ventricle, the powerful force-pump which propels the blood for nourishment to all the tissues, including the head and lungs themselves. This in contracting forces the blood through the semi-lunar valves into the aorta, which gives off first the coronary arteries to the heart itself, then arches over the base, giving off large vessels to the head and shoulders, and finally passes down the chest close to the backbone, giving off vessels as it goes. These pass into capillaries, and these again into

veins, which pour their contents into the venæ cavæ as before. The following scheme exhibits the circulation:—

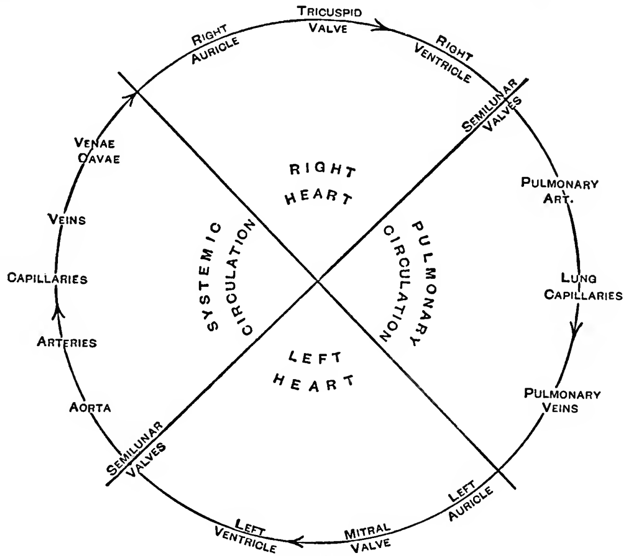


Fig. 24.

Since the heart supplies itself with blood by means of the coronary arteries, and since the regularity of its movements depends on the quality and quantity of the blood supplied to it, it will be seen that the heart occupies a unique position among the vital organs. It is like a runner in a hurdle race who has so many obstacles to surmount; it is of no consequence whether the leap be graceful or not provided he gets over, but let him miss one hurdle and he is seriously handicapped for taking the rest. So should the rhythm of the heart be interfered with by disease, violent exercise, or drugs, each stroke missed means that the heart muscle becomes loaded with its own "fatigue-products", and is less and less able to take the next step.

Some hours after a full meal a great amount of additional matter is poured into the blood from the digestive system, and this gives rise to the feeling of fulness; the blood pressure is increased and may give rise to headaches, &c. In such a case

the remedy is to withdraw the blood from the head as much as possible, either by bathing the feet and legs in hot water so as to relax their vessels, or by evacuating the bowels so as to induce an increased flow to them, or by open-air exercise, which fetches the limb muscle into play and withdraws blood in their direction.

SUMMARY.

1. Blood is conveyed from the heart by arteries, to the heart by veins.
2. Arteries are distinguished from veins by the nature of their walls, the presence of a pulse in them, and the absence of valves.
3. Exchange of materials between blood and tissue takes place in the capillaries, these materials being liquids and gases.
4. The circulation is maintained by pressure due to the heart's action.
5. The heart consists of two parts, each with collecting and propelling chambers, and having no connection with each other.
6. The right side of the heart is respiratory, being concerned with venous blood only.
7. The left side of the heart supplies the system, and is occupied with aërated blood only.
8. Both parts of the heart work together, and in rhythmic order, according to the cardiac cycle.
9. The heart is the first organ to be supplied with blood, and is therefore the first to feel the effects of bad blood.

Lesson 20.—RESPIRATION.

In the early lessons of this book it was shown that the body resembled a steam-engine in that it was a machine for the production of energy, and that, like the steam-engine, it produced that energy by chemical means from food which served it as fuel. But for combustion there is required not merely fuel but oxygen, and a certain temperature above or below which the various chemical changes involved cannot go on, or do so imperfectly. This temperature in our case is **blood-heat**, about 39° C. (98–99° F.), and it seems to be the temperature best suited to the activity of the living cells, which after all are the working elements of our frame. A rise of a very few degrees above this constitutes fever, and a slight fall leads to

collapse. The question of heat-balance of the body, and how it may be affected by diet, will be discussed when dealing with the skin.

The great supporter of combustion in this planet is the oxygen of the air, and **Respiration** may be defined as the interchange of gases between the blood and our environment. Strictly speaking, respiration occurs wherever there are living cells supplied with blood, for the hæmoglobin of the red corpuscles carries thither supplies of oxygen and receives in return carbonic acid gas and water, the products of combustion in the cell, but it is customary to restrict the term respiration to the processes that go on in the lungs.

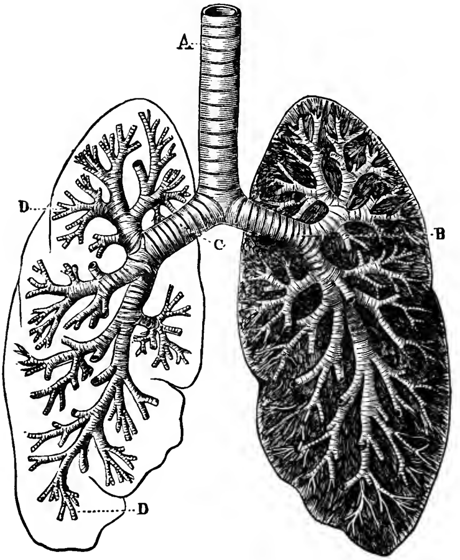


Fig. 25.—Bronchial Tubes.

The **mechanism of respiration** consists of the trachea or windpipe, the bronchial tubes, and the air-cells, the two latter constituting with the requisite blood-vessels the substance of the lungs. The *Windpipe* consists of a series of half or three-quarter rings of cartilage or gristle, closed at the back by a membrane, and it lies in front of the gullet. To prevent food from passing "down the wrong throat" it is guarded at the top by a valve of elastic cartilage, the epiglottis, which folds down when food is passing; and in addition the windpipe is pulled upwards and forwards under the tongue, as may be felt by pressing "Adam's apple" while swallowing. Unlike the gullet, the windpipe is always open, and along with the bronchial tubes is lined with mucous membrane. This keeps the internal surface soft and moist, and to prevent mucus

from clogging the finer tubes they are all furnished with ciliated cells, *i.e.* cells provided on their free surfaces with minute hair-like structures, which by a kind of lashing motion cause a current towards the mouth. This ciliated epithelium is found in the windpipe and bronchial tubes, but not in the air-cells; and the effect of this motion is to sweep out in a stream of mucus any foreign particles, such as dust, which have found entrance into the lungs.

When a bronchial tube is traced to its termination it is found to expand into a compound pouch, like a bunch of

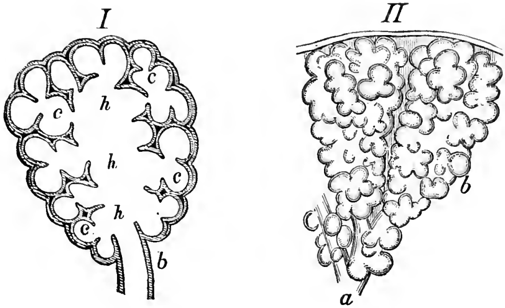


Fig. 26.—Air-cells of the Lung.

grapes. This is an *Infundibulum* or air-cell, and here the walls are so thin as to offer no resistance to the passage of gases from the cell to the very elaborate meshwork of capillaries outside, and *vice versa*. The surface of the air-cells has been reckoned at about 100 times that of the entire surface of the body.

The foregoing structures make up the structure of the **Lungs**. These are two in number, right and left, the right lung having three lobes and the left only two, owing to the greater space taken up on that side by the heart. They receive blood for their own nourishment by the bronchial arteries, and that blood returns to the right side of the heart in the usual way by the bronchial veins; but they also receive from the right ventricle the two large pulmonary arteries conveying impure blood, and they return that blood when aërated to the left auricle by the pulmonary veins. There is here, therefore, an instance of an artery conveying "venous" blood, and *vice versa*. The connective tissue surrounding the air-cells and forming

a supporting framework is highly elastic, and this elasticity comes into play in breathing.

Like the heart, the lungs are enclosed in a double sac known as the *pleuræ*, the outer layer being attached to the chest wall, and the inner to the surface of the lung. The other parts concerned in ordinary breathing are the ribs, with the intercostal muscles lying between them, and the vaulted floor of

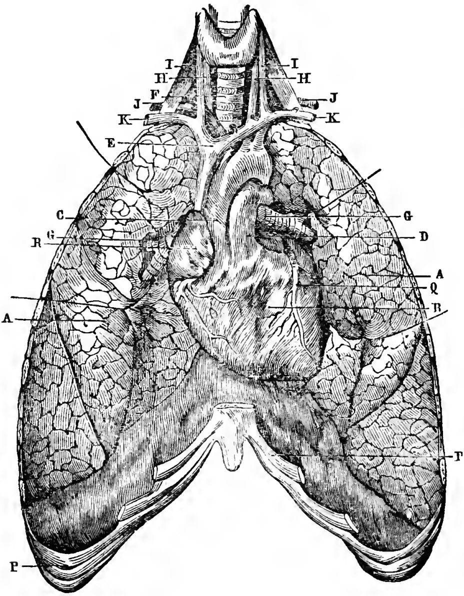


Fig. 27.—The Heart with its Blood-vessels and the Lungs.

A, The lungs pulled aside in front to show the heart, B, and the bronchi, G, G; C, the aorta; D, the pulmonary artery; E, the superior vena cava, formed by the junction of the veins (subclavian) from the right and left sides, K, K; F, the windpipe; I, I, veins from the head and neck (jugular) joining K, K; H, H, arteries (carotid) to head and neck; J, J, arteries (subclavian) passing to right and left sides; P, P, ribs; Q, left coronary artery; R, right auricle.

the chest called the *diaphragm* or midriff. The intercostal muscles are so arranged that, when they contract, the upper and middle ribs are raised, and the chest expands forwards and upwards, as may be seen in women, in whom breathing is chiefly "costal", carried on by the ribs. In men, on the other hand, breathing is effected chiefly by the diaphragm, which in contracting pulls down the floor of the chest and the lower ribs, displacing the abdominal organs, whence this type of breathing is called "abdominal" breathing. By the joint action of the intercostal muscles and the diaphragm the chest is expanded at regular intervals, 15 to 20 per minute, and the

lungs are dilated with air upon the concertina principle, air rushing in through the windpipe to equalize the air-pressure in the lung, which, owing to chest expansion, would otherwise be less than the pressure of the air outside. Relaxation of the lungs is due solely to their elasticity, the muscles being in the resting phase. A breath thus consists of an inspiration followed by an expiration, and these recur at regular intervals at the rate of about 18 per minute, or one to every four heart-beats.

The **amount of air** taken in at each inspiration is not great, 15 to 20 cubic inches, and this is called the *tidal* air. If after an ordinary expiration an attempt be made to empty the lungs there will be expelled 100 cubic inches of *reserve* air, but there will still remain in the lungs, beyond muscular control, another 100 inches of *residual* air. On the other hand, by an effort of will, after an ordinary inspiration another 100 inches of air can be inhaled, and this is called *complemental* air. These may be exhibited in tabular form thus:—

100 in.	complemental	These three constitute the "respiratory capacity" of the individual.
20–25 ,,	tidal - - -	
100 ,,	reserve - -	
100 ,,	residual - -	

The respiratory capacity increases with the body-weight up to $11\frac{1}{2}$ stones in the male, then diminishes at the rate of one cubic inch per pound; it increases with age up to 30 or 35, then diminishes about $1\frac{1}{2}$ inch per annum. It is greatly increased by the use of dumb-bells and such exercises as swimming, which specially develop the chest, and is proportionately diminished by stooping, tight clothing, &c.

In order to form an idea of the **chemistry of respiration** we have to examine the air inspired and expired, and also the blood in the pulmonary arteries and veins. The dark "venous" blood going to the lungs comes back bright scarlet, with its hæmoglobin oxidized, and the blood-gases richer in oxygen and poorer in carbonic acid. When the expired air is compared with that inhaled, corresponding changes are observed. Atmospheric air contains about 79 per cent of nitrogen and 21 per cent of oxygen, together with a very small amount of carbonic acid gas, ·04 per cent, and water vapour, which, like the temperature, depends on the weather. The air expired, however, is saturated with moisture nearly at blood-heat, has lost oxygen and gained carbonic acid, while the nitrogen is unchanged, as shown below:—

Inspired.			Expired.
Nitrogen ...	... 79·02	...	79·02+
Oxygen ...	... 20·94	...	16·158, loss 4·782 per cent.
Carbonic acid ...	·04	...	4·42, gain 4·38 per cent.
Water ...	... variable	...	saturated.
Temperature ...	variable	...	warmer, 36·3° C., almost blood-heat.

Expired air always contains small quantities of organic matter from the lungs, and it is this putrescible matter which causes the offensive "smell of human beings" observed in ill-ventilated rooms, for pure carbonic acid has no odour. It will be observed that the increase of carbonic acid, 4·38 per cent, is not quite equal to the loss of oxygen, 4·782, the rest of the oxygen being used to form water. The ratio $\frac{\text{carbonic acid}}{\text{oxygen}}$ $\left(=\frac{4·38}{4·782} \text{ or } ·9\right)$, is the "respiratory quotient", and is fairly constant, so that the amount of carbonic acid formed may be taken as an indication of the oxygen used in the lungs. Since we inhale 20 or 25 cubic inches of air at each breath, and breathe 18 times per minute, an easy calculation will give the amount of air used daily, and $\frac{1}{5}$ of this may be set down as oxygen, giving 18 cubic feet of oxygen used, or the air of a cubical room 7 feet each way. The carbonic acid given off represents nearly half a pound of solid carbon burnt in the tissues, and the water lost by the breath is 9 fl. ozs., or nearly half a pint. As compared with the skin, the loss of carbonic acid is much greater by the lungs, but the loss of water not nearly so great, the total loss by the skin being half as much again as that by the lungs.

Since the air inhaled at a breath, the "tidal" air, is only about one-eighth of that already in the lungs, the part played by diffusion in exchanging gases between the lungs and the blood must be very small, and this brings into prominence the two other factors in respiration, chemical action and the **vital activity** of the living tissues concerned. The oxygen of the air in the lungs is less in proportion than that of the atmosphere, and the proportion diminishes as air gets deeper into the lung; still, the oxygen of the air-cells is greater in proportion than that of the blood, and that again greater than in the tissues. There is thus from outside air to tissue a descending scale of oxygen, but an ascending scale of carbonic acid, thus:—

Oxygen of air > lungs > blood > tissues.
Carbonic acid of tissues > blood > lungs > air.

Strange to say, the number and depth of respirations have no influence on the amount of carbonic acid formed; they simply influence the carbonic acid already made by changing the reserve air. Active persons excrete more carbonic acid, and the effects of **Exercise** in this respect are most marked, as shown by the following table from Parkes:—

AIR INSPIRED.

Lying, ...	1·	Walking 3 miles an hour and carrying 118 lbs., ...	4·75
Sitting, ...	1·18	Walking 4 miles an hour, ...	5·00
Standing, ...	1·33	Walking 6 miles an hour, ...	7·00
Singing, ...	1·26	Riding and trotting, ...	4·05
Walking 1 mile an hour, ...	1·90	Swimming, ...	4·33
Walking 2 miles an hour, ...	2·76	Treadmill, ...	5·50
Walking 3 miles an hour, ...	3·23		
Walking 3 miles an hour and carrying 34 lbs., ...	3·50		

Unity being 480 cubic inches of air per minute.

The growing period of life, distinguished by chemical and vital activity, is also marked by an increase of carbonic acid, the proportion in a child being double that of an adult, and this increases till maturity, after which it diminishes. Sunlight increases the amount of carbonic acid produced, showing that more oxygen is used.

For the present purpose it is important to note the effects of **Food**. About an hour or so after a meal the carbonic acid is increased, owing to the increased chemical activity in the digestive system. Quality of food has a marked effect, carbonaceous foods, *i.e.* carbohydrates, and notably fats, which contain 80 per cent of carbon, greatly increasing the amount of carbonic acid. It was the great liberation of energy in the shape of heat that gave to these foods their old name of heat-givers.

SUMMARY.

1. Respiration is exchange of gases between the blood and the air.
2. Tissue respiration occurs in the capillaries; respiration proper in the lungs.
3. The mechanism of respiration comprises air-cells in the lungs; conducting tubes, the bronchial tubes and windpipe; and respiratory muscles to expand the chest.
4. At each breath the lungs receive only about $\frac{1}{8}$ of their capacity, being already well filled with air.

5. Exchange of products is thus due as much to vital and chemical action as to diffusion of gases.

6. Expired air has lost oxygen, gained carbonic acid and water, and has been warmed to nearly blood-heat.

7. The amount of carbonic acid evolved, and therefore of oxygen used, is greatly increased by exercise and by carbonaceous food, and generally by increased chemical activity in the body.

Lesson 21.—THE KIDNEYS AND URINE.

Not only do the lungs serve to oxygenate the blood, but they also serve as excretory organs, removing from the body two waste products especially, carbonic acid and water, the former from the combustion of carbon, the latter from that of hydrogen. Besides the liver and bowels, the other organs concerned in the removal of waste are the kidneys and the skin, both engaged in the removal of water and salts as urine or sweat, and *nitrogenous* waste, with the removal of which last the lungs have nothing to do except for the small amount of organic matter which passes off in the breath.

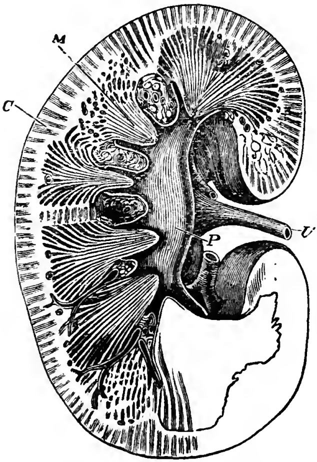
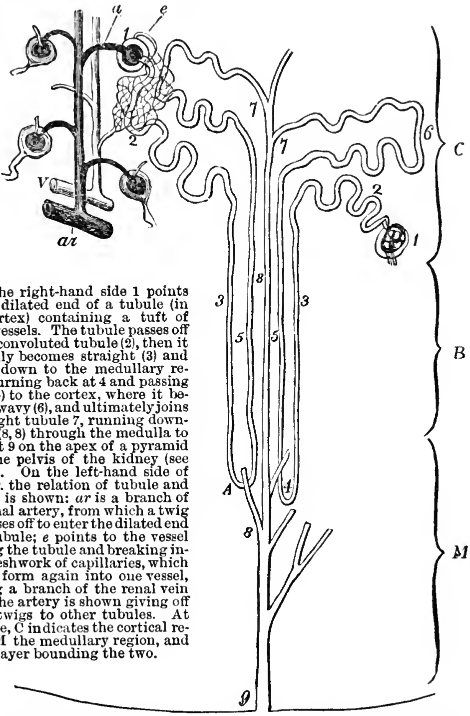


Fig. 28.—A Kidney opened in its length.

C, Cortical portion; M, medullary portion; P, pelvis; U, ureter.

The mechanism for the excretion of urine comprises the kidneys, ureters, bladder, and urethra. The **Kidneys**, called of old "the reins", are two in number, situated on either side of the backbone high up in the loins, and covered by masses of fat. In man they are about 4 inches by $2\frac{1}{2}$, and present the characteristic kidney shape, but are smooth on the surface, not lobulated like those of the ox. Each kidney is covered by a capsule or skin, and this passes on to cover the ureter or collecting tube. These leave the kidneys at the inner hollow, and into the same place pass the blood-vessels, renal arteries, and

veins, very large for the size of the kidney. When cut open the kidney is seen to be a tubular gland composed of numerous urinary tubules about $\frac{1}{600}$ inch in diameter, running more or less directly from the capsule to the centre, where they are caught up into groups or pyramids as shown on page 108,



On the right-hand side 1 points to the dilated end of a tubule (in the cortex) containing a tuft of blood-vessels. The tubule passes off as the convoluted tubule (2), then it suddenly becomes straight (3) and passes down to the medullary region, turning back at 4 and passing back (5) to the cortex, where it becomes wavy (6), and ultimately joins a straight tubule 7, running downwards (8, 8) through the medulla to open at 9 on the apex of a pyramid into the pelvis of the kidney (see fig. 28). On the left-hand side of the fig. the relation of tubule and vessels is shown: *ar* is a branch of the renal artery, from which a twig (*a*) passes off to enter the dilated end of a tubule; *e* points to the vessel leaving the tubule and breaking into a meshwork of capillaries, which finally form again into one vessel, joining a branch of the renal vein (V). The artery is shown giving off other twigs to other tubules. At the side, C indicates the cortical region, M the medullary region, and B the layer bounding the two.

Fig. 29.—Diagrammatic View of the Tubules and Blood-vessels of the Kidney.

and pour their contents into the open pelvis or collecting basin from which the ureter rises. These tubules are very complicated in structure, and are supplied with blood after the fashion of the portal system. Each tubule originates near the outer surface in a hollow cap or ball, called a Malpighian body, which receives a little blood-vessel from the renal artery. Within this ball the vessel breaks up into loops of capillaries which reunite as usual to form a vein; but instead of proceeding

direct to the renal vein, this again forms capillaries, spreading themselves over the twisted portions of tubule immediately outside the capsule (fig. 29). There is thus in the kidney on a small scale the same double set of capillaries already met with in the portal system. It would seem that in the malpighian bodies *water* is separted from the blood by the simple process of filtration under pressure, so that the higher the blood-pressure in the kidney the more water will be excreted. In birds, which have no malpighian bodies, the urine is solid. The solid constituents of urine are excreted chiefly by the cells of the convoluted tubules supplied by the second set of capillaries, so that the quality and quantity of urine are determined by two factors, the blood-supply and the vital activity of the urinary cell.

From the kidneys urine is conveyed to the bladder by the **Ureters**, tubes 14 inches long and about the thickness of a piece of slate-pencil. These lead to the **Bladder**, a muscular bag lined with mucous membrane as usual, and here the urine accumulates till the increasing pressure induces evacuation by the urethra.

The amount of **Urine** thus excreted is 50 fl. ozs., or $2\frac{1}{2}$ pints daily in males, in females rather less. When freshly voided it is acid, owing to the presence of acid phosphate of soda, but on standing it decomposes and becomes alkaline from formation of ammoniacal compounds. The chief mineral constituent of urine is common salt, which gets into urine by reason of its great solubility, and has thus to be supplied with food. The urine also contains sulphates from oxidation of sulphur in albumen, and phosphates by oxidation of the phosphorus in proteid matter and bone. By far the most important substance in urine, however, is the organic substance **Urea**, which represents the bulk of the nitrogenous waste of the body. It contains half its own weight of nitrogen, and the amount excreted daily is 500 grs., or rather more than 1 ounce. Urea is formed outside the kidney, chiefly in the liver, and is present in small quantities in all blood, and also in measurable amount in sweat. It is partly formed in the kidney as well as the liver, and is removed by the former organ. The amount of urea excreted does not depend on exercise, as was at one time supposed, but on the quality of the *food* taken, being increased by rich proteid or nitrogenous diets; indeed, if more albumen be ingested than what is required, some may appear in the urine unchanged.

Another nitrogenous compound of importance is **Uric Acid**, and in animals with solid urine this occurs instead of urea. Accumulation of uric acid in the blood characterizes gout, and since urates are not very soluble, they tend to be deposited in the bladder, giving rise to gravel or stone. The use of lithia-water in gout is based upon the fact that urates of lithia are pretty soluble, and so have a better prospect of being removed in urine.

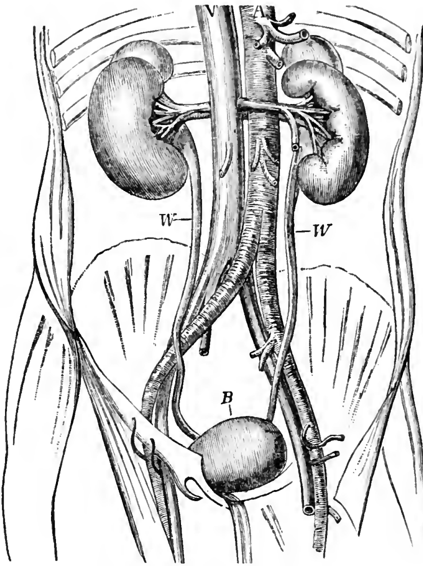


Fig. 30.—The Situation of the Kidneys.

A, Aorta; V, vena cava; B, bladder; W, ureters. Branches of the aorta are seen going to the kidney, and veins from it are shown joining the vena cava.

Besides these substances, urine contains hippuric acid; pigments derived, like those of bile and fæces, from the red corpuscles of blood; various extractives; and mucus from the bladder. Its specific gravity is about 1020, but this is subject to large fluctuations. After copious draughts of water the urine becomes more watery, while after severe muscular exercise, accompanied by copious perspiration, the specific gravity may be high, since in that case most of the water has been removed by the skin and lungs. The urine first passed in the morning, "night-urine", is always denser than that at any other period of the day.

The kidneys, lungs, and skin are all concerned in the **excretion of water**, though in man the kidneys excrete more than the lungs and skin together; but after violent exercise the proportions may be reversed, and the ratio of water excreted by skin and lungs to that excreted by the kidneys may rise from ·5 or ·8 : 1 up to 2 or $2\frac{1}{2}$: 1. Here, too, man

occupies a position between herbivora and carnivora, inclining towards the latter, as the following table shows:—

In man the kidneys remove	60%	of the total water,	lungs and skin	40%
„ herbivora „	30%	„	„	70%
„ carnivora „	70%	„	„	30%

There are two substances whose presence in urine is of the utmost importance, inasmuch as it may indicate serious functional derangement—sugar and albumen. To test for **albumen in urine**, heat a little urine in a test-tube; the albumen if present will coagulate, and will remain undissolved on adding acetic acid. In the normal condition all nitrogenous waste appears in the form of urea, uric acid, &c., and is eliminated as such. The presence of albumen in urine, therefore, indicates that assimilation of proteids is not proceeding properly, or that there is something wrong with the organs concerned in the production of urea, viz. the liver and kidneys. There are some people who can never take a hearty breakfast of ham and eggs without having albumen in the urine, but in the great majority of cases such symptom shows disordered metabolism, generally indicating, when permanent, some form of Bright's disease.

In laying down a diet for disorders of this kind, the object in view is to remove from the blood those products of albuminous waste for which the urine is the natural outlet, and so to give food sufficient to maintain the system, but entailing the least amount of work upon the digestive organs, and furnishing the minimum amount of albuminous waste. Such a food is Milk, and accordingly, in all cases of albuminuria, where the structure of the kidney is not very largely involved, a purely milk diet will be found to encourage the flow of urine and the formation of the normal urinary products, while giving the diseased kidney as little to do as possible. When the symptoms amend, the patient may gradually return to the ordinary mixed diet, always avoiding excess of nitrogenous foods.

The other substance abnormally present in urine is **Sugar**, in the form of dextrose, characteristic of the disease known as diabetes. In previous lessons it was shown that all carbohydrates, starches, and sugars become converted in digestion into dextrose or grape-sugar, which finds its way into the liver by the portal vein, though a small quantity may get into the blood by the lymphatic system and the thoracic duct. In the

liver this sugar is converted into glycogen or liver-starch, and thus prevented from immediately passing into the blood. As already seen, according to Bernard's theory of **Glycogenesis**, the liver acted as a storehouse for carbohydrates till such time as they could be reconverted into sugar, thus distributing over 24 hours the sugar with which the blood would otherwise be loaded after every meal. When the sugar did enter the blood in these small quantities, Bernard held that it was consumed in the capillaries like ordinary fuel, liberating muscular energy and animal heat, and producing as waste products carbonic acid and water. On this theory the presence of sugar in urine indicated, on the one hand, failure of liver function owing to the liver cells not forming glycogen, or transforming it into sugar again too rapidly, or too great a flow of blood through that organ, as if the cells had not time to separate the sugar; or, on the other hand, that the sugar liberated by the liver was not being used up by the tissues, the vital fire, as it were, burning badly and giving off unconsumed fuel as smoke in addition to the ordinary products of combustion.

The other theory of the glycogenic function is due to Pavy. He admits that the liver arrests sugar from the digestive canal and changes it into glycogen, but he denies that this glycogen is again transformed into sugar. The small amount of sugar always found in blood, says he, is traceable to the sugar which reaches the blood from the thoracic duct, and any sugar which appears in the urine is directly proportional to this amount of sugar in the blood. On this view the liver not merely *arrests* sugar, but *assimilates* it, transforming it into glycogen, which may be further changed into fat. As already mentioned (p. 87), most authorities are returning to Bernard's theory. In any case, what occurs in diabetes is failure in the utilization of sugar, and that is due to failure of the action of the liver, either from disorder of the liver itself, or possibly from disorder of the sympathetic nervous system, thus permitting a too-rapid passage of blood through the liver.

The dietetic treatment of glycosuria is based upon these facts, and simply consists in withholding from the patient all foods which can be turned into sugar within the organism, *i.e.* all carbohydrates. In very severe cases, however, sugar is formed out of nitrogenous materials, and even at the expense of the muscles; this may be said to be incurable by dietetic means. Food will thus be as much as possible restricted to proteids and fats with water; combined, especially in patients

who are inclined to be sedentary, with plenty of muscular exercise, which greatly increases the consumption of sugar within the body. The "personal equation" in the matter of carbohydrates seems to be considerable; the ingestion of fruit-sugar (levulose) is not generally accompanied by the appearance of sugar in the urine, and the same is true of milk-sugar. The dietetic rules for such cases have been drawn up by Professor See as follows:—

1. Reduce to a minimum, or abolish altogether, all sugar-forming foods.

2. Raise to the physiological maximum all flesh foods, *i.e.* give as much animal food as can be well digested and assimilated.

3. Replace the carbon of carbohydrates by the various animal and vegetable fats.

4. Promote muscular activity to consume the excess of sugar in the blood.

SUMMARY.

1. The kidney is a compound tubular gland devoted to the removal of water, salts, and nitrogenous waste.

2. In removing water it is assisted by the lungs, bowels, and skin, so that when these are active the amount of water removed by the kidneys is proportionably less.

3. The total amount of solids removed in urine is actually greater than that removed by the bowels.

4. Nitrogenous waste takes the form of urea, uric acid, &c., and of the former there are excreted 500 grains per day.

5. Albumen and sugar are abnormal products in urine, the former indicating defective assimilation of proteids, the latter failure of liver action, due to liver or nervous disorder.

Lesson 22.—THE SKIN.

The other exit by which waste products pass out of the body is by the **Skin**, and in order to explain its functions its structure demands attention.

The skin consists of two parts, an epidermis, cuticle, scarf-skin or false skin (fig. 31, *a*) covering the dermis, chorium or true skin below. The upper skin is destitute of blood-vessels and nerves, as may be seen by inserting a needle under it, and

it is the part separated in a blister. It grows from below upwards, and is continually being shed in the form of minute scales, best noticed in the scalp as "scurf", so that in this way there is a considerable loss of nitrogenous matter. The upper layers are horny in structure, and similar in composition to nails and hairs, which are indeed developments of it. In its lower layers (*b*), the epidermis contains colouring matters which impart the various shades of skin to the different races of men. The red tint of the skin is due to the blood of the true skin below. The epidermis serves to protect the delicate structures below, as may be evidenced by the intense pain felt when a blister is broken, and the raw surface exposed even to the air. It also exercises a certain amount of pressure on the capillaries, and thus a raw surface is always moist, and in this way it prevents adjacent parts from growing together, as raw surfaces tend to do.

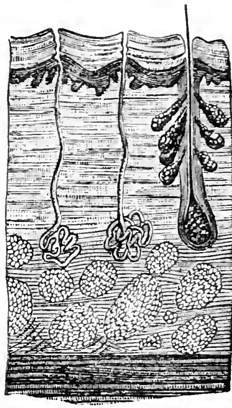


Fig. 31.—The Structure of the Skin.

The epidermis of the fingers especially is thrown into ridges (fig. 31, *b*), and these are caused by rows of little projections called *papillæ* on the surface of the true skin below. They are about $\frac{1}{100}$ inch high, and are plentifully supplied with blood-vessels and nerves ending in touch-corpuscles; upon the number of these last depends the sensitiveness of the skin as an organ of touch. The mass of the true skin is ordinary connective and elastic fibres; it is plentifully supplied with blood, and below it lies a more open subcutaneous tissue with fat cells (fig. 31, *d*).

The surface of the ridges on the fingers may be observed to be dotted at short intervals. These little pits are the openings of **sweat glands**, tubes originating in the epidermis but penetrating the true skin, and generally terminating by coils in the fatty tissue below (fig. 31, *c*). Although these sweat glands are very small, their numbers make up for this. Krause estimated their number at $2\frac{1}{2}$ millions, giving 1000 square metres of secreting surface, and it has been calculated that if uncoiled and placed end to end they would extend to over 20 miles! Associated with the hairs, and opening into the hair sheath, are the **oil glands**, distinct in structure, resembling a bunch of

grapes, and furnishing sebum, a natural hair-oil. In new-born infants this oily covering is very pronounced, and consists of epidermic scales with nearly half its weight of fat, chiefly palmitin and olein. When the sebaceous glands get choked, a sebaceous tumour or wen is often the result. The wax glands of the external ear are modified *sweat* glands.

Perspiration or **Sweat** is the chief form of loss of substance by the skin. It is always flowing, though rarely observed except in hot weather or after violent exercise, and the daily loss is about 2 lbs., $\frac{1}{67}$ of the body-weight, or half as much again as the loss by the lungs. Like most fluids of the body it is alkaline, though in rheumatism it becomes acid. There is only 1·2 per cent of solid matter in it, and of the solids the chief is urea (·1 per cent). The secretion of sweat is intimately associated with the blood-supply, being influenced by any cause which sends an increased amount of blood to the skin. Thus, increase of temperature, increase of general blood-pressure, watery blood, diaphoretic drugs, might all conduce to sweating, and when one remembers the connection between the skin, lungs, and kidneys, it is at once seen that injury or disease of these last organs will to a certain extent be compensated by increased activity in the skin. The bearing of this upon cleanliness is obvious; the skin should be washed all over with soap and warm water to remove its oily covering, and then rubbed well down with a hard towel to remove scurf, &c., and stimulate the blood-vessels and glands.

It is in virtue of its blood-supply that the skin exercises its chief function, **regulation of the bodily temperature**. When the bodily temperature rises above the limit of safety there is an automatic reflex action through the vaso-motor centre in the brain, resulting in relaxation of the surface blood-vessels, flushing of the skin, and a copious excretion of sweat. This not merely reduces the blood-pressure, but by evaporation from the surface cools down the body generally, and over and above, there is a great loss of heat by direct radiation from the surface. In this connection it may be well to submit a balance-sheet of the body with respect to heat.

The amount of heat in the body, animal heat, is derived from oxidation of food-stuffs, especially of the carbon and hydrogen in them, and is measured in calories, 1 calorie being the amount of heat required to raise 1 gram of water 1 degree Centigrade. Our **heat income** may then be stated as under:—

Proteids in food,	120 grams, containing	64·18 carbon and		8·60 hydrogen.	
Fats do.,	90 „ „	70·20	„	10·26	„
Carbohydrates,	340 „ „	146·82	„	—	
	Total,	281·20	„	18·86	„
	less unconsumed in excreta,	29·8	„	6·3	„
	Total available for heat production,	251·4	„	12·56	„

But each gram of carbon, oxidized to carbonic acid, produces 8040 calories, and each gram of hydrogen, oxidized to water, produces 34,460 calories; multiplying our available carbon and hydrogen by these factors we have:—

$$251{\cdot}4 \times 8{,}040 = 2{,}031{,}312 \text{ calories.}$$
$$12{\cdot}56 \times 34{,}460 = \quad 432{,}818 \quad „$$
$$\text{Total} \quad = 2{,}464{,}130, \text{ say } 2\tfrac{1}{2} \text{ million calories.}$$

Now for the **heat expenditure.** The waste products leaving the body—urine, fæces, and expired air—are all heated to nearly blood-heat, and there is a considerable amount of heat used in evaporating water from the lungs and skin, as under:—

1,900 grams	excreta heated 25° C.	= 47,500	calories, or	1·9 %
13,000 „	air „ „	84,500	„	3·38
330 „	water evaporated by the lungs,	192,060	„	7·68
660 „	„ „ „ skin,	384,120	„	15·37
	Total heat loss from these sources,	708,180	„	28·33
	Remainder lost by radiation from skin,	1,791,820	„	71·67
		2,500,000	„	100%

It is thus seen that the skin alone by evaporation of sweat and radiation accounts for 87 per cent of the total heat loss, a fact of the first importance in estimating its functions.

Besides the secretion of sweat, there are **other functions of the skin.** Thus it removes a small amount of carbonic acid, up to $\frac{1}{3}$ ounce, and so may be classed with the lungs as a respiratory organ. The oxygen absorbed by the skin is, however, only $\frac{1}{180}$ of that by the lung, and the carbonic acid even less. In frogs, on the other hand, the proportions are quite reversed, and in them from $\frac{2}{3}$ to $\frac{3}{4}$ of the total carbonic acid are eliminated by the skin.

A slight amount of absorption goes on by the skin. Owing to its oily covering, water and water solutions are not absorbed. but ointments may be rubbed into the skin to attain that end. If the epidermis be rubbed off, so as to expose a raw surface, absorption is rapid, and this is a fertile source of blood-poisoning from wounds. Absorption is still more rapid when a substance

is introduced by a hypodermic syringe into the looser subcutaneous tissue.

The functions of the skin may be summed up as follows:—

Regulation of temperature.	Respiration.
Secretion of sweat.	Absorption.
Secretion of sebum.	Protection and touch.

SUMMARY.

1. The skin consists of two parts, an upper skin and the true skin.
2. The latter is an organ of touch, and is chiefly concerned with regulating the bodily temperature.
3. The bodily temperature is lowered by radiation and evaporation of sweat, and will be lowered in proportion to the amount of blood sent to the surface.
4. Conversely, if blood is sent from the skin to the more internal organs the body temperature rises.
5. Loss by the skin is due to sweat, sebum, scurf, and a small amount of urea and carbonic acid.

Lesson 23.—METABOLISM.

Looking at the human body merely as a machine for the production of energy, we have seen that it requires fuel and air, both obtained from without. This fuel, which we call food, is presented to us not in the crude shape of carbon, hydrogen, nitrogen, &c., nor even as the proximate principles fat, albumen, starch, sugar, but as food-stuffs, each of which may contain representatives of all these principles, and withal be more appetizing in appearance. These are to be regarded as storehouses of energy, so much bottled sunlight like Stephenson's coal, energy stored up in past days by plants and animals in the shape of formed tissues and the complex chemical compounds of animal and vegetable substances, all formed out of the simple inorganic materials by process of reduction. Now comes in man, and by the opposite chemical process, that of oxidation, breaks up these complex bodies into others simpler and simpler, until at last they have liberated well-nigh the last particle of energy stored in them, and have become again stable inorganic matter. Plants are thus constructive, animals destructive; plants roll the ball up-hill, animals send it down

again; plants act the miser parent, animals the spendthrift son; and so all the parts of this little world dovetail into each other and form a grand cycle of matter, and that which acts on matter—force. This stored or **potential energy** is by us converted into **kinetic energy**, energy liberated in the shape of heat and work, and to this transformation, including all the changes of substance involved, the name **Metabolism** is given, meaning by that the constant change and interchange of matter between the organism and its surroundings. It has the same relation to the body as the terms import and export trade have to a country.

In order to prepare foods for digestion, and also to increase their attractiveness of appearance or flavour, food is cooked in various ways; but in all cases their history within the body is the same—the carbon in them leaves the body, 90 per cent of it as carbonic acid by the lungs and skin, the rest in the urine and fæces; their hydrogen is eliminated as water by the kidneys, skin, lungs, and bowels, more water thus leaving the body than is taken in; nearly all their nitrogen within twenty-four hours as urea, by the kidneys, and about 2 per cent of it as uric acid, kreatinin, &c.; their sulphur and phosphorus as sulphates and phosphates in urine, along with other mineral matters; and their oxygen in combination with the above. The intermediate stages of metabolism are not so clear. Fats are easily burned up to form carbonic acid and water, and are thus the great source of energy, readily obtainable, and so sparing the tissues, especially the muscles, from drawing upon themselves. This "albumen-sparing action of fats" is readily illustrated by the use of cod-liver oil and other fats in wasting diseases. The energy of fats would seem to be derived from the fatty acids rather than from glycerin, since the use of the latter alone is not followed by the same results.

In the case of carbohydrates, the process is clear up to a certain point; they become dextrose, and in the liver this is converted into glycogen, but the further history of glycogen wants working out. With proteid foods again, matters are still more obscure; by the gastric and pancreatic juices they are peptonized, but in the process of absorption become changed into serum albumen. Some of this goes to nourish the tissues, a small proportion only, otherwise a gain in body-weight would be the result. This is the so-called "fixed" albumen, as opposed to the "circulating" albumen which is utilized as a source of energy like other food principles. Some

of this very likely forms fat, and it certainly does so in fatty degeneration; but whatever the intermediate stages, albumen certainly leaves the body in much simpler forms, in the putrefactive products of the intestine and the several organic matters in urine, but above all as uric acid and especially urea. Outside the body these are further oxidized into carbonic acid, water, and ammonia.

Returning to the figure of an engine; just as some coals are better than others for steam-raising purposes, so certain foods contain a greater store of chemical energy than others. Thus, for heat-giving purposes, as measured by a calorimeter, it was seen on p. 17 that fat was far above other foods, and in the proportions quoted these foods are said to be *isodynamic*, *i.e.* capable of yielding equal amounts of energy. It is one thing, however, to burn foods in a calorimeter, and quite another thing to digest them within the body. Thus albumen, gelatin, and the keratin of the nails and horn, have a similar chemical composition and are nearly equal in dynamic powers, and yet everyone knows that gelatin is worth only one-third of the same weight of albumen, while horn clippings are simply indigestible. Or, to take a more practical case, starch and cellulose are identical in chemical composition and calorimetric results, but starch, whether as potato starch or in the more expensive but not more useful arrowroot, is easily digested, while cellulose as eaten in most vegetables is as indigestible as in its familiar form of paper. One must not be misled, therefore, by analyses which profess to show a certain amount of nitrogenous or carbohydrate foods; it is necessary to know in what precise condition these principles are, for they may be of such a nature as to be wholly useless to the body, if not irritating or worse.

The average **amount of energy** put out daily by a working-man is 300 foot-tons, *i.e.* as much as would be required to lift a ton 300 feet vertically upwards, or roughly, as much as is expended in a 16-mile walk by a person of average weight. In order to raise this amount of external work the body has to liberate 1500 foot-tons per day of internal energy, mostly in the shape of heat; so that the body is capable of yielding $\frac{1}{5}$ of its total energy in the shape of mechanical work, whereas the very best steam-engine transforms little more than $\frac{1}{8}$ of the chemical energy of the coal into work.

By various processes, mechanical, chemical, and vital, the ingested materials are converted into fluids or emulsions, which

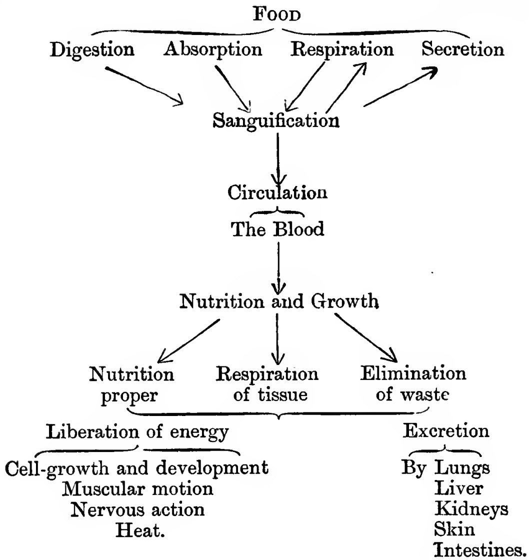
finally become somehow part of the blood. The heart propels them to all parts of the organism, bathing the tissues in lymph by exudation and supplying with both nutriment and oxygen, receiving in return their waste products and unused lymph by both the venous and lymphatic vessels. The glands and other organs concerned in digestion draw their raw material from the blood, and from it also the kidneys, &c., excrete various waste matters; while the lungs, in addition to removal of waste, supply the body with oxygen.

The last and most important stage in the whole process is **Assimilation**. How do the tissues exercise their mysterious selective powers, and take from the blood only those things they require, and so out of these dead matters form living muscle, nerve, and so on? This takes us into the whole mystery of life, and the relation of soul (ψμχη) to body; and all that can be said to-day is that of the process of assimilation we know nothing at all. Certain it is that a person may have an enviable appetite, good digestion, perfect absorption, and unimpaired circulation, but his food gets no further than blood, the body is not benefited to anything like the proper extent, remaining thin and emaciated, and the blood so plentifully produced simply relieves its own pressure by escaping on the slightest provocation, as by bleeding at the nose. It is possible that this mysterious function may be connected with the nervous system, just as diabetes, a similar disturbance of assimilation, may be traced to disorder of the sympathetic nervous system, but in these matters the "personal equation" bulks largely. "What is one man's meat is another man's poison", and so Macbeth's salutation receives an additional force—

> "Now good digestion wait on appetite,
> And *health* on both".

A very good bird's-eye view of the functions of the body is presented in the scheme from Prof. M'Kendrick's *Outlines of Physiology*, given on the following page.

SCHEME OF METABOLISM (M'KENDRICK).



SUMMARY.

1. The body transforms potential or stored energy into kinetic energy, displayed as work and heat.

2. Of the potential energy in food and oxygen the body can show $\frac{1}{5}$ as mechanical work, amounting to 300 foot-tons per day.

3. The greater the fuel properties of a food the more energy can be got out of it, fats in this respect being *facile princeps.*

4. Metabolism is the name given to the physiological changes concerned in the transformation of energy.

5. Assimilation is the process by which the living cells of the body take up the materials supplied to them by the blood.

6. Chemically speaking, the whole metabolic process is one of oxidation, and the food appears under the final forms of carbonic acid, water, urea and kindred substances, sulphates, phosphates, &c.

Part IV.—FOODS IN DETAIL.

Lesson 24.—MILK.

Among animal foods there are two provided by nature for the support of the young—milk and eggs. These are sometimes called complete or perfect foods, because they contain in the proper proportion all the materials for the upkeep of those for whom they are intended, the young mammal and embryo chick respectively. Although milk is admirably adapted for infancy—and an invalid has often to return to infantile diet,—still it is far too deficient in carbohydrates to be proper food for adults.

The analysis of average cow's milk shows the following composition:—

Water, 82–90 per cent; average 87·5 per cent.
Solids, 18–10; not less than 12 in good milk.
Solids not fat, up to 11; 8·5 is the minimum standard of the S.P.A.
Proteids, 3·5.
Fats, not less than 3; 4 in good milk.
Sugar (Lactose), 5.
Ash, 0·6.

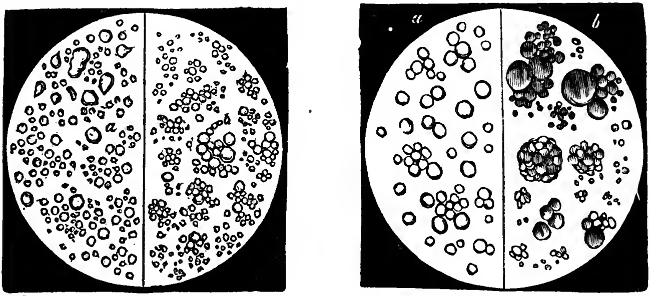
Fig. 32.—Lactometer.

Milk has a characteristic odour, and shows in human milk an alkaline reaction. The milk of carnivora is always acid from the presence of lactic acid, while cow's milk may be alkaline, neutral, or acid. They all become acid on standing, owing to the formation of lactic acid, and at the same time oxygen is absorbed and carbonic acid evolved.

The specific gravity of milk, as tested by the lactometer, varies from 1026 to 1035. The lactometer, as shown in the figure, is a glass bulb weighted below with mercury to make it float upright, and having a long graduated stem. The denser the milk the greater its buoyancy, and the stem is well out of the liquid, while in water the stem should sink to the mark 0, indicating 1000. Since butter is lighter than water the effect of skimming the milk is to raise the specific gravity of the milk, since skim-milk is proportionally heavier than whole milk; and if now water be added, the specific gravity will be lowered to its

former point, although the milk has been impoverished in these two ways. Hence specific gravity alone, as shown by the lactometer, is not a sufficient test of the richness of milk, but must be combined with the direct estimation of the fat. This is generally 4 per cent, and by the regulations of the Society of Public Analysts must not be less than 3.

When milk is boiled there is formed on the surface a scum consisting of lact-albumen coagulated by the heat, with a thin skin of altered casein and some entangled fat globules; it is thus very nutritious and should not be thrown away, as is often



Oil Globules of Human Milk. Oil Globules of Cow's Milk. × 319.

Oil Globules of Human Milk. Colostrum with Corpuscles. × 450.

Fig. 33.—Microscopic Appearance of Milk.

done. In the process of making Devonshire or clotted cream a similar change takes place; the milk is heated in pans for hours under the boiling-point, and not only is the milk-albumen coagulated as above, but all lactic-acid germs are killed, and the cream consequently keeps for days if the jar be unbroken.

In structure, milk is an *emulsion*, consisting of fine oil globules swimming in a colourless liquid or plasma, as shown by this scheme—

Milk an emulsion.
- Suspended matters.
  - Oil globules.
  - Fine granular casein.
- Plasma = Matters dissolved in water.
  - Lactose or milk-sugar.
  - Casein, associated with phosphate of lime.
  - Albumen in solution.
  - Peptones.
  - Colouring matter.
  - Salts, chiefly phosphate of lime and potash compounds.

The chief proteid in milk is **Casein**, or rather caseinogen, the substance which when coagulated forms casein, but usually kept in solution by its association with phosphate of lime. The curdling of milk resembles in many respects the coagulation of blood, since it demands "casein-factors", viz. caseinogen, certain salts, notably those of lime, and a milk-curdling ferment. In ordinary cases this ferment is *Rennet*, derived from the stomach of the calf, and its action seems to be that it decomposes caseinogen into casein and whey-albumen. Cow's milk forms in the stomach large clots of curd, while human milk curdles as a granular mass; hence the need of treating cow's milk in some way before giving it to infants. This is very simply done by adding *boiling* water, which coagulates the albumen but not the casein, followed by a little lime-water or barley-water. The effect of lime-water, which is alkaline, is partly to neutralize the acid gastric juice and so enfeeble it that the casein is curdled only by slow degrees; this, however, is an interference with the work of the stomach, and barley-water is to be preferred. The latter acts mechanically in virtue of its mucilaginous nature, keeping the particles of casein from clotting together into large masses, and it is moreover nutritious in itself. Casein is easily formed in the granular condition by adding acids to milk, but the granular casein thus obtained is said to differ considerably from that curdled by rennet. When milk is curdled by rennet "sweet whey" is formed, and the reaction is alkaline; the casein here is partly precipitated as curd, and slightly dissolved into whey-albumen. Milk for infants may thus be prepared by adding a few drops of lemon juice, as in making "humanized" milk, to be described later.

Milk-fat, or **Butter**, consists of glycerides of stearin, olein, palmitin, and other neutral fats, containing the characteristic acid, butyric acid. In human milk-fat there is twice as much olein as there is of palmitin and stearin together, whereas in cow's butter the proportions are about equal; cow's butter is therefore firmer in consistence. More fat is absorbed in proportion to proteid matter in milk, and fresh butter is the most easily digested form of all fats. Persons whose stomachs reject cod-liver and similar oils should have no difficulty, therefore, in obtaining a supply of fatty food in this very palatable form.

When milk is skimmed, as in the old style of creaming, the cream removed contains almost all the fat, with a small proportion of casein, which always tends to accompany the fat.

Skimmed Milk, therefore, contains most of the casein, albumen, and milk-sugar, with the water, and is thus highly nutritious though watery. Skim-milk generally contains 1 per cent of fat, but the modern centrifugal process of separating cream removes it much more thoroughly, so that "separated" milk contains no fat to speak of. In this process the whole milk is whirled rapidly, and just as air-bubbles and other light materials collect in the vortex of a whirlpool, so the oil-globules which constitute cream collect in the centre of the separator, while the heavier portions, consisting of plasma, are driven to the circumference, the extraction of both cream and separated milk proceeding continuously.

In connection with this, it may be mentioned that in the case of tuberculous milk the tubercle bacilli, being solid bodies and relatively heavier than plasma, are driven to the extreme circumference of the separator, and are found thickly accumulated in the "glut" which covers that part of the machine. In this way there may be obtained from infected milk, cream, and even separated milk, prefectly free from tubercle and other germs.

Butter-milk contains all the constituents of milk, even fat, to the extent of 1¼ per cent, and it is never altogether fat-free. The sourness of butter-milk is due to lactic acid, developed at the expense of lactose or milk-sugar, under the influence of the lactic-acid bacillus, and the proportion of lactic acid tends continually to increase. It is absent, of course, in milk newly drawn from the cow, but soon gets it from the air, and in a few hours is present in appreciable quantity. "Turned" or soured milk has been allowed to decompose by natural fermentation in this way; the casein is clotted by the lactic acid produced, and there are formed at the same time various bye-products which combine to render soured milk unwholesome. The lactic acid ferment acts more rapidly in warm weather, as is well known by the difficulty of preserving milk in summer. Lactic acid combines with zinc, forming lactate of zinc, and milk should therefore never be kept in zinc vessels.

Various methods have been devised for the **preservation of milk**, but they may be classed as—(1) evaporating processes; (2) addition of chemicals; (3) application of cold; (4) heat and then cold. The condensed milk now so largely used is of two kinds, sweetened and unsweetened, the former having 22 per cent of cane-sugar added. The milk is evaporated in a vacuum-pan so as to remove most of its water at a temperature under

coagulation-point, and the semi-solid mass thus obtained is kept in hermetically-sealed tins. Sweetened condensed milk can be exposed to the air for a considerable time without decomposing, owing to the antiseptic action of the sugar in it, but the unsweetened milk should be used as soon as possible after opening the tin. The average composition of condensed milk is—water, 26; nitrogenous matters, 12; fat, 11; lactose, 16; and cane-sugar, 22 per cent. In the same way milk may be evaporated to complete dryness, producing desiccated milk, which keeps indefinitely.

There are several substances added to milk to arrest decomposition, and among these may be mentioned glycerin, 2 per cent; baking-soda, 1 in 1000; salicylic acid, 1 in 500; boracic acid;—the last two very commonly used—sulphur dioxide gas passed through it after boiling, or a little sulphite of soda added to produce the same effect. If boiled in a flask, and sealed, the milk remains in vacuo, and may be kept for years. The addition of a pinch of baking-soda and cane-sugar will preserve milk, even without boiling, for ten to fourteen days. Within the last year a very powerful antiseptic has been discovered in Scherin's formalin, a very small proportion of which, 1 in 10,000, arrests decomposition for months.

When milk is frozen, as in making ice-cream, a better sweeter cream is the result, but cold alone does not kill germs of disease, and as ice-cream shops are often in the hands of foreigners who have their own notions of cleanliness, it is highly desirable that, as in Glasgow, these places should be placed under the same stringent regulations as apply to dairies. By first heating milk, in order to arrest incipient fermentation, and then applying cold, this difficulty could be overcome.

Coming now to milk as an article of diet, it will be interesting to compare the milk of various animals used as food, and the table on p. 128 exhibits a comparison of those most commonly used in this way. (Blyth.)

Ewe's milk is distinguished by a large amount of solids, especially fat and casein, along with a large amount of soluble albumen.

Goat's milk is also rich in fat and casein, and is thus highly nutritious, though least digestible of all. It is poor in sugar, and is apt to be disliked on account of its peculiar smell, due to a characteristic acid.

Mare's milk resembles human milk very closely, but is rather poorer in solids, chiefly fat and casein. Like human milk it is

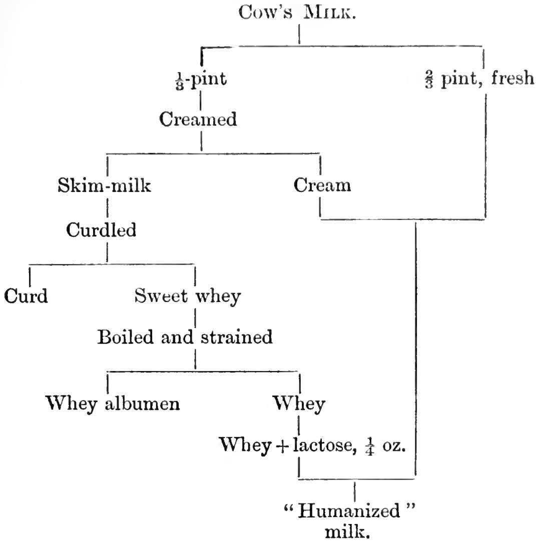
rich in sugar, and advantage is taken of this to prepare from it the beverage *Koumiss*, by alcoholic fermentation.

	Human.	Cow.	Ass.	Goat.	Mare.	Sheep.	Camel.	Cat.
								Carnivorous.
Milk-fat, ...	2·90	3·50	1·02	4·20	2·50	5·30	2·90	3·333
Casein, ...	2·40	3·98	1·09	3·00	2·19	6·10	}	3·117
Albumen, ...	·57	·77	·70	·62	·42	1·00	} 3·84	5·964
Peptone, ...	·10	·17	·10	·08	·09	·13	}	·467 =·25 peptone.
Sugar, ...	5·87	4·00	5·50	4·00	5·50	4·20	5·66	4·911 (including acids).
Ash, ...	·16	·70	·42	·56	·50	1·00	·66	·585
Water, ...	88·00	86·87	91·17	87·54	88·80	82·27	86·94	81·623
Total Solids, ...	12·0	13·12	8·83	12·46	11·2	17·73	13·06	18·377
Solids not fat, ...	9·1	9·62	7·81	8·26	8·7	12·43	10·16	15·044
Specific gravity,	1031·3	1033	—	—	—	1038–41	—	—

Ass's milk is poorest of all in solids, though the sugar is almost the same as that in human milk, so that it is a sweet milk. It is deficient in fat and casein, and is thus easily digested by invalids whose stomachs cannot tolerate cow's milk.

Cow's milk, as will be seen from the table, is richer than human milk in everything but sugar; hence when given to infants it must be diluted with boiling water to three times its bulk to begin with, and after a month or so half and half, and a little sugar added. The coagulation of cow's milk within the human stomach has already been mentioned. Strictly speaking, the sugar added to cow's milk to bring it up to the human standard should be lactose, which is generally prepared from whey, and thus contains some of the milk-salts. It is claimed that lactose has not the same tendency as ordinary sugar to undergo acetic fermentation, but it is said, on the other hand, that it is more ready than the latter to become lactic acid, while it is comparatively clear. The following has been given as a recipe for "**humanized" milk.** Allow $\frac{1}{3}$ pint of new milk to stand for 12 hours; call this No. 1. Cream this, and add the cream to $\frac{2}{3}$ pint of fresh milk; No. 2. By means of rennet curdle the skim-milk of No. 1 from 5 to 15 minutes; break up the curd when formed, and separate all the whey. Rapidly heat this whey by boiling, which coagulates the whey albumen, called "fleetings", and strain through muslin to remove this. In the hot whey dissolve 110 grains, say $\frac{1}{4}$ oz.,

of lactose and mix it with No. 2. Use within 12 hours. The process may be shown by a diagram, thus:—



The amount of milk secreted by an average cow is from 2 up to 5 gallons per day. The quality and quantity of milk depend upon various factors, such as the age of the cow, number of pregnancies, being least with the first. The age of the calf influences the quality, for, as in human milk, the first milk or "green" milk, called colostrum (see fig. 33), is of a purgative nature, intended to clear the bowels of accumulated bile. The idea of "one cow's milk" for infants is a popular superstition, for though the danger of "green milk" is thereby avoided, a far more uniform milk is obtained from the mixed milk of large dairies, where for the exigencies of city supply the period of calving is spread over the whole year. Food has a powerful effect upon milk, as can be very well seen in feeding cattle with turnips and fragrant grasses; so also has breed, Alderney cows yielding milk richer in fat, long-horns richer in casein, while for quantity nothing beats Ayrshires.

The first milk drawn off is poorest in fat, that drawn last is the richest, and the difference between "fore" milk and "strip-

pings", or "afterings", is very marked. Fraudulent dairymen, with no higher fear than that of an inspector, have been known to carry "strippings", known as "fear" milk, so as to supply that functionary on demand, and Professor Blyth tells how an unscrupulous farmer may try to damage an analyst's reputation by submitting for analysis "fore" milk drawn off before witnesses. The analysis of such a milk would, of course, show a low percentage of fat, and the effect would be to lower the standard of purity in the minds of the local authorities. The minimum insisted on by the S.P.A. is 8·5 per cent of solids not fat, and not less than 3 per cent of fat, but in good milk 4 per cent of fat should be looked for. Professor Blyth gives the following comparative analyses of "fore" milk and "strippings":—

	Devon Cow.		Guernsey Cow.	
	Fore.	Strippings.	Fore.	Strippings.
Specific gravity, ...	1·0288	1·0256	1·040	1·023
Milk-fat, ...	1·166	5·810	·357	5·946
Casein, ...	2·387	4·304	4·708	3·435
Albumen, ...	1·830	·975	·451	·860
Peptones, ...	·381	·545	·267	·156
Lactose, ...	3·120	3·531	4·943	5·280
Ash, ...	·797	·895	·874	·929
Water, ...	90·319	83·940	88·400	83·394
Common salt in ash, ...	·340	·267	·100	·098

The total amount of dry solids in a pint of milk is only 2½ ozs., and, therefore, in order to obtain the 23 ozs. of dry solids for ordinary needs, a man would require to take 9 pints of milk daily. This would give the body far too much water, while fats and proteids would also be in excess; hence in order to redress the balance carbohydrates are needed, and these are generally supplied in the form of bread, rice, or other starchy foods.

The question is often asked, What should a nursing mother take to improve her milk? At first sight it would seem that a fatty diet would be required to increase the proportion of butter in the milk, but this is so far from being the case that increase of fat in the food rather *diminishes* the amount of fat in the milk. Sugary diets have no marked effect, as milk-sugar appears to be derived from proteids, and not from

carbohydrates at all, so that the common practice of taking stout and similar beverages is a mistake. These increase the milk, but only in respect of quantity, the result being the same as if the milk had been watered. It is found that the diet best calculated to improve the quality of the milk is a rich one, *i.e.* a proteid diet with a small amount of vegetables. Not only is the quantity of milk increased, the casein, sugar, and fat are also increased. The casein in the milk is formed by the milk-glands out of materials supplied to them by blood and lymph; these glands are paralysed by atropin (belladonna). The mental and physical state of the mother powerfully affect the composition of her milk, and infants have even been dosed with "medicated" milk, for certain medicines administered to the mother, such as chloral, rhubarb, opium, &c., pass into the milk, and so affect the child.

SUMMARY.

1. Milk is a complete food, *i.e.* containing the proportion of all the proximate principles required for young mammals.
2. Its chief solid constituents are casein, lactose, and butter, about 4 per cent of each.
3. Milk is deficient in carbohydrates, and has to be supplemented by bread or other farinaceous foods.
4. It contains only 2½ ozs. of solids to the pint, and is therefore unsuited for an adult, who would have to take 9 pints daily.
5. Human milk differs from cow's milk in being poorer in everything except sugar.

Lesson 25.—MILK DERIVATIVES. BUTTER.

Besides cream and skim-milk there are obtained from milk butter and cheese, including the bye-products butter-milk and whey. The analysis of *Butter* is given by Blyth as follows:—

Fat,	...	79–94;	average,	83·11	per cent.
Casein,	...	1–3;	„	·86	„
Lactose,	...	·70;	„	—	
Salt,	...	0–7;	„	1·19	„
Water,	...	14–5;	„	14·14	„

A little casein always tends to accompany milk-fats, but when this casein is in excess it decomposes and causes the butter to

become rancid. On melting a sample of butter in a test-tube, it should show not more than one-third of casein by weight, or one-third to one-half by bulk.

The fats of butter are chiefly palmitin and olein, but always with these are small quantities of the volatile fatty acids, chiefly caproic and *butyric*, to which butter owes its peculiar odour. If a sample of butter be heated in a test-tube it froths if pure and gives off the peculiar butyric odour, whereas if adulterated with lard or tallow the smell of these compounds is at once perceived. Another way of testing butter is by melting it, and lighting a piece of wick immersed in the oil; any butryic or tallowy odour is at once discovered. The specific gravity of butter is also a fair test; pure butter is fairly heavy, ranging from 911 to 913, and it melts at 95° F., while adulterated butter has a specific gravity of 902 to 904, and artificial butter is lighter still, from 859 to 861, melting at 86° F. The presence of margarine in butter is easily recognized by the microscope in the following way:—Smear a cover-glass with butter so as to get a very thin film, and examine it on a slide by transmitted light; if the butter be pure the film appears homogeneous, but if adulterated crystals of margarine appear.

When butter, or any fat, is warmed with potash or soda, either caustic or carbonate, it is saponified as explained in lesson 6, and this furnishes another means of distinguishing pure from adulterated butter.

Salt is always present in butter, fresh butter even containing from $\frac{1}{2}$ to 2 per cent, the usual proportion being 8 grs. per ounce. Salt added for the sake of preservation need not exceed 7 per cent, so that when butter is very salt there is reason for suspecting that the extra salt has been added to conceal commencing decomposition. Butter may be preserved by covering it with water containing a 3-per-1000 solution of acetic or tartaric acid, and keeping it in a close vessel. The addition of sugar with a little salt serves the same purpose.

Fresh butter is the most digestible form of fat, and children who cannot stomach fats as a rule may obtain their necessary quantity of this principle more simply and agreeably in this form. Like all fats it is a rich storehouse of energy, in this respect giving fully double the amount of heat got from the same amount of carbohydrates or proteids. While good butter is good, bad butter is decidedly bad, and any good

artificial butter is greatly to be preferred to badly prepared butter. The well-earned reputation of Danish butter has been due to the almost paternal supervision shown by the Danish government in respect of preparation and packing, and it has completely ousted Irish butter from first place, though there is some likelihood of that place being yielded to butter from Australia and New Zealand.

Butter-milk, like skim-milk, is a food prized not nearly so highly as it ought to be. It contains all the constituents of milk, for owing to the association of casein and fat already mentioned, it is never free from fat. Two analyses are given below:—

No. 1.		No. 2.	
Water,	90·62	Average total solids,	9·43
Casein,	3·78	Solids not fat,	8·56
Fat,	1·25	Fat,	·7
Lactose,	3·38	Salts,	·75
Lactic acid,	·32		
Salts,	·65		

Some of the lactose in the milk is changed into lactic acid, and the proportion of the latter tends to increase, causing the sourness of butter-milk, and latterly precipitating casein, while by the absorption of oxygen and evolution of carbonic acid gas the milk may froth up. It is to the pressure of lactic acid in butter-milk that the latter owes its usefulness in baking; of course, when baking-soda is used with it there is formed lactate of soda, which remains in the bread.

In cases of indigestion, when the stomach is weak from any cause, such as catarrh or ulceration, a distinguished specialist has said: "When the patient is thirsty, let him drink butter-milk; when the patient is hungry, let him eat butter-milk"; and the consideration of the composition of butter-milk abundantly justifies his opinion. For purposes of comparison, an analysis of **Skim-milk** may be useful.

Water,	88·0	90·63
Proteids,	4·0	3·06
Fat	1·8	0·79
Lactose,	5·4	4·77
Salts,	0.8	—

From this it will be seen that all the solids not fat are contained in skim-milk, and therefore its specific gravity is high. In skim-milk proper there is always a small amount of fat, ·8 to 1 per cent, but in milk separated by the centrifugal

process this fat almost entirely disappears, being reduced to ·5 or ·1 per cent only.

So much has been said about the distinction between real and artificial butter that it may not be amiss to describe the manufacture of the latter. By the Act of 1887 all butter substitutes are known collectively as **Margarine**, instead of butterine, though in the United States the name oleo-margarine is used. In order to produce margarine from animal fat, the fresh fat is freed as far as possible from foreign matter, skin, muscle, connective tissue, &c., then it is passed through a sort of mincing-machine called the "hasher", which breaks it up into small pieces. These now go to melting-tanks, which are warmed on the glue-pot principle by water contained in an outer vessel, and the heat is maintained at or below 39° C. As the melting proceeds, scum rises to the surface, and this is skimmed off, leaving the oil floating on the heavier water. The oil is now decanted into wooden "coolers", when the stearin, being the least soluble of the fats, begins to crystallize, and its separation is further encouraged by removal to the cooler atmosphere of the press-room, kept at from 26·5° to 32° C. The separated stearin is removed by filtration through cotton cloths, and the process is completed by pressure, the stearin remaining in the presses as a hard cake, while the softer margarine is forced through. The latter is now coloured to imitate butter, and churned with milk to give it the butyric flavour, when it is ready for food. It is used either alone as margarine, especially for cooking purposes, or churned with butter to form various "mixtures" for table use.

There can be no doubt at all as to the high value of margarine as a food. Many of the so-called "mixtures" contain over 90 per cent of pure butter, and are thus, even as butter, superior to inferior articles of that name. The prejudice against margarine is rapidly disappearing in towns, and a "mixture" at from 7*d.* to 9*d.* the pound can more than hold its own against butter at 10*d.* or 1*s.*, even for table purposes, while for baking, the cheaper kinds are quite as good as butter and half the cost. On the other hand, it is said that there is 1·6 per cent more absorbed of artificial than of natural butter.

SUMMARY.

1. Butter consists almost entirely of fat (80 per cent) and water, with a little casein and salt.

2. It is the most digestible form of fat, and is specially suitable for children and invalids.

3. Skim-milk and butter-milk contain all the solids of milk except fat, and are thus highly nutritious, while lighter of digestion than milk.

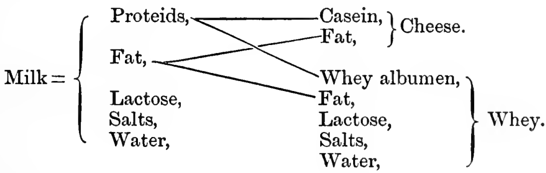
4. Butter-milk is specially useful as a basis of diet in stomach disorders.

Lesson 26.—CHEESE.

The second great milk derivative is **Cheese**. In making cheese, milk in whole or part is warmed to about 80° F., and then curdled by rennet, then the curd is minced, strained, coloured with annatto, salted, and finally pressed into shape in wooden moulds, care being taken to expel all the whey.

Whey, thus formed as a bye-product, contains the natural salts of milk, potash and lime compounds; all the milk-sugar; whey-albumen, due to the action of rennet upon caseinogen already explained; and a little fat. Cheese, again, contains all the casein and some of the fat, but none of the natural milk-salts, their place being taken by common salt, a matter of some importance in the use of cheese as food.

The following scheme represents the process of cheese-making:—



The cheeses when formed are stored in a moderately warm place, and there undergo the change called "ripening". In this process their fats increase at the expense of the proteids, and the casein becomes more soluble, perhaps owing to the formation of albuminate of soda, and even semi-fluid like peptone. At a later stage, leucin and tyrosin are formed, also at the expense of casein, along with butyric and valerianic acids, so that the whole ripening process bears a close resemblance to that of proteid digestion in the intestines. In decomposing, cheese is apt to be attacked by various moulds —green, blue, and red,—also by cheese mites, the larvæ of

Acarus domesticus, and maggots or "jumpers", the larvæ of the cheese-fly. There is occasionally produced in it a poisonous ptomaine, tyrotoxicon or cheese-poison, a substance also found in milk which has been kept for three or four months.

Cheese may be classed as "hard" or "soft". The latter are produced at a low temperature with little pressure, and are mostly alkaline, while "hard" cheeses are acid at first, and demand higher temperature and pressure. Among common soft cheeses are English cream-cheese; Neufchatel; Brie, which decomposes rapidly and is made for immediate use; and Roquefort, which is made from ewe's milk, and which, like other cheeses of that kind, tends to sour and cause diarrhœa.

Of hard cheeses there are several varieties, depending on local manufacture or on the proportions of milk employed. Stilton cheese is made from whole milk and cream; Cheddar and double Glo'ster from whole milk; single Glo'ster from whole milk and skim-milk, and therefore very rich in proteids, but apt to be hard, and consequently difficult to digest; American and Dunlop, mostly made from whole milk. To this class also belong Parmesan, Gruyère, Gorgonzola, and skim-milk cheeses, Dutch and others. The following analyses show the composition of representative cheeses (Parkes):—

Cheese.	Water.	Fat.	Casein.	Lactic Acid.	Ash.
American (red),..........	28·63	38·24	29·64	—	3·49
Cheddar, medium, ...	35·60	31·57	28·16	0·45	4·22
Cheshire, ...	37·11	30·68	26·93	0·86	4·42
Single Glo'ster,...........	35·75	28·35	31·10	0·31	4·49
Dutch, ...	41·30	22·78	28·25	0·57	7·10

Of late there have appeared in our markets, chiefly from America, two varieties of cheese, "filled" and "oleo"-cheese. In evidence before the select committee of the House of Commons on food adulteration, it was stated that in several places there was no sale for skim-milk during the summer, because of the abundant supply of whole milk. Producers of the former had thus to convert it into cheese, but as skim-milk cheese was too hard and coarse for the popular taste, oleo-margarine had to be introduced to render the article finer as well as to supply its deficiency of fat. This "oleo"-cheese is quite a wholesome article of food, though not so wholesome as whole-milk cheese,

still, superior to cheese made from skim-milk without the addition of fat. Analyses of Dunlop, oleo-cheese, and Gorgonzola show the following proportions of fats and casein:—

	Dunlop.	Oleo-cheese.	Gorgonzola.
Butter fat,..................	31·68	11·32	26·99
Other fats,..................	none.	16·98	6·75
Casein,........................	32·30	32·64	26·16

"Filled" cheese is a term employed to distinguish certain cheeses sent from the Western States. They are made chiefly of lard, and look very like whole-milk cheeses, but they corrupt very quickly, especially in hot weather, and in spite of their admixture the lard and casein refuse to blend intimately, as may be seen by leaving a slice of filled cheese on a plate in a warm place; the lard will be found nearly all melted out next morning. Of course, if either oleo-cheese or filled cheese are palmed off upon a consumer as whole-milk cheese, that is a distinct infringement of the Food and Drugs Act; whether oleo-cheese can be legally sold as a skim-milk cheese is at present a moot point.

Cheese as a food-stuff is remarkable as presenting a large amount of nutriment in small bulk, one pound of cheese containing as much nitrogenous food as two pounds of meat, and as much fat as three pounds. Against this must be set the fact that cheese is apt to be indigestible, especially in the skim-milk forms, but for men working in the open air and called upon for a great output of mechanical work, cheese will be found to be a very serviceable diet. The common opinion that cheese aids digestion is founded upon a mistake. A German chemist digested cheese in a digestive fluid containing fresh gastric juice, and found that, while an ordinary meal took 4 to 5 hours to digest, cheese required 4 to 10 hours. Much of the indigestibility of cheese will be found to be due to imperfect preparation, either of mastication or of cooking, as well as to the absence of the natural salts of milk, especially potash. In making cheese, common salt or chloride of sodium is added, but soda salts cannot replace those of potash in the animal economy, and in this connection the late Professor Williams has pointed out that cheese warmed with carbonate cf potash is completely liquefied. The mechanical difficulty

may be overcome in the harder forms by grating the cheese, but even here methods of cooking leave much to be desired. When cheese is toasted, its fat melts and parts with some water, but if the heat be continued, or if the cheese be poor in fat to begin with, the only effect of heat is to harden the casein and convert it into a horny indigestible mass, such as is formed when an egg is over-fried. It is quite true that a slight amount of indigestible matter stimulates the action of the bowels, but to render food indigestible is culpable waste as well as ignorance.

Before leaving the subject of milk it may be useful to recall the unique position this substance holds with respect to the spread of zymotic diseases. Scarlet fever and diphtheria have again and again been traced to milk-supply, the milk having been infected in the first instance by the milkers or others recovering from these diseases. It is now demonstrated that there is a cow scarlatina, and probably a cow diphtheria, and these may infect milk apart from human origin. Such diseases as enteric fever and cholera can only be spread by milk through a polluted water-supply, the water being used either for diluting the milk or for cleansing cans, milk-pails, &c. Can tuberculosis be communicated by milk? The question is fully answered in the report of the Royal Commission presented April, 1895, and its conclusions may be briefly given thus:—Tuberculous cows with healthy udders gave milk free from tubercle bacilli; even when fed with tuberculous matter they still gave healthy milk. When the udder was diseased, but *post-mortem* examination revealed no tubercle, again no tubercle bacilli occurred in the milk; but when the udder disease was tuberculous the bacilli were found in milk. Obviously, since a post-mortem examination cannot be held in every case of udder disease, the simplest plan is to examine the milk microscopically in every such case, and, if the tubercle bacillus is found, to condemn the milk and prevent it from passing into consumption. The tubercle bacillus is so easily killed by application of heat that all that is required to sterilize infected milk is to bring it to the boil—it need not be kept boiling,—since the bacillus is killed by a temperature of 40° C. Children dislike the flavour of boiled milk, and it is certainly less digestible than fresh milk, but this is a small matter compared with the immunity conferred. The action of centrifugal separators on tubercle bacilli has already been noticed.

Since milk affords such a happy hunting-ground for disease germs, and since cold alone is powerless to kill these germs, it is much to be regretted that the manufacture of ice-cream is still unregulated. Ice-cream shops are usually conducted by people whose notions of cleanliness are, to put it mildly, continental, and evidence in connection with the Glasgow Police Act abundantly showed that zymotic diseases have been communicated by this agency.

SUMMARY.

1. Cheese consists of almost equal parts of water, fat, and casein, with 4 per cent or so of salts.
2. It is very nutritious, 1 lb. cheese being equal in nitrogenous matter to 2 lbs. meat, and in fats to 3 lbs. meat.
3. Cheese, especially in the harder forms, is difficult of digestion, and needs preparation by mastication or cooking.
4. It retards digestion, although small portions of old cheese may act as digestive stimulants.
5. Milk is specially notorious as a vehicle for disease germs, notably tuberculosis, scarlet fever, and diphtheria, while typhoid is often spread by the use of infected water in dairies.

Lesson 27.—EGGS.

Eggs form another natural perfect food, in this case for the embryo chick. It must be borne in mind, however, that in this the shell plays a considerable part, as may be seen by a comparison of its relative thicknesses when laid and when newly hatched. The shell consists chiefly of chalk, carbonate of lime, and magnesia, and as growth proceeds these salts are partly dissolved by phosphoric acid formed from the phosphorus in the yolk. The eggs most commonly used for food are those of the hen, duck, goose, turkey, and guinea-fowl. They are all suitable for food, and their differences of quality and flavour depend upon the feeding of the birds, as is seen especially in the delicate flavour of plovers' eggs. In composition they are much alike; duck eggs contain more fat than hens'. The average weight of a hen's egg is 2 ozs., containing nearly 200 grains of solids, divided as follows:—10 parts shell, 60 parts white, of which 86 per cent is water, and 30 parts yolk containing 52 per cent of water; or 100 grains of egg = 10 grains

shell + 22·8 grains albumen and fat + 67·2 grains water. As a food they are very deficient in carbohydrates, but richly nitrogenous, and more of their nitrogenous constituents are absorbed than of their fats.

White of egg consists of egg-albumen dissolved in water and enclosed in a delicate membrane. It contains much less fat than the yolk, and is more fluid; the salts in it are chiefly chlorides. It is said that the practice of eating eggs raw is attended with the appearance of albumen in the urine, but this is denied, and in any case the albumen found in urine is not egg-albumen but serum-albumen. A slight degree of cooking completely destroys any such tendency where it exists. Egg-albumen coagulates at the comparatively low temperature of 73° C., the same as the albumen of meat, while vitellin or yolk-albumen coagulates at 75° C. At first sight this would seem to be contradicted by the results usually obtained in cooking, but a little thought will show that the ordinary practice of boiling eggs is a mistake. The effect of subjecting eggs to the heat of boiling water is much the same as in roasting meat, but without the same justification, since the egg is already provided with a shell; the outer albumen is hardened and so acts as a protective casing to the inner portion or yolk. If, instead, the temperature were maintained at say 73° C., the heat would penetrate the whole egg, which would be found in that delicious curdy condition which marks the perfection of egg cooking. Eggs, therefore, are best cooked when put into cold water and brought to the boil, or, better, kept at 75° long enough to cook their albumen to the centre.

The **Yolk** differs from the white in several important aspects, and, as might be expected from its peculiar functions, is very complex in composition. It is rich in fat, chiefly olein and palmitin, but contains also cholesterin and yellow pigment, besides the peculiar nitrogenous fat, lecithin, found also in nervous tissue. It is from the phosphorus in yolk-albumen that there is derived glycero-phosphoric acid, which helps to dissolve the shell and form a phosphate of lime. The yolk also contains extractives, grape-sugar, and salts, chiefly phosphates and *iron* compounds. The presence of sulphur is indicated by the formation of sulphuretted hydrogen when eggs decay, and so, to avoid the formation of sulphides, egg-spoons are either gilt or made of non-metallic materials. On account of the phosphorus, yolks of egg are forbidden to gouty patients; but they prove valuable in cases of anæmia, owing to the compara-

tively large amount of iron present. For such purposes the yolks may be administered switched in milk. In some people the habitual use of eggs is said to induce nettle-rash.

"Lait de poule" is made by beating up yolks in hot water, then adding sugar and some aromatic flavouring such as orange-flower water. The common practice of adding rum and brandy to eggs is generally mistaken; the alcohol coagulates the albumen into a hard cheesy mass, as may be seen by dropping an egg into spirits.

An egg is never more digestible than when newly laid, since its albumen gets less digestible daily. As will be seen from the table of gastric digestion on p. 60, they are most digestible when switched raw, and the more they are boiled the more cheesy and indigestible do they become, hard-boiled egg being the most indigestible form of albumen known. If, however, a hard-boiled egg is finely grated the albumen is readily dissolved by the digestive juices. The common practice of baking eggs in puddings is thus entirely wrong; so far from the presence of eggs making such puddings "light", it increases their indigestibility; and for invalids a light custard without eggs will be found more easily tolerated by the stomach and assimilated by the tissues. The "lightness" is really due to the introduction of air in the process of "whipping" the eggs, and the egg-albumen is thus presented, not in mass, but finely divided; still, the tendency is to overload puddings with eggs, in the mistaken search for richness.

As an egg becomes old its unstable organic matter decomposes, giving off various gases, sulphuretted hydrogen and others. Thus the egg becomes lighter and opaque, and these may be used as a test of freshness. A fresh egg, examined against the light, should be perfectly homogeneous, whereas in decay a dark spot may be observed at the top, owing to the development of an air-space. If a 10-per-cent solution of salt in water be made, 2 ozs. to the pint, a good egg will sink, and an indifferent one will float; a bad egg may float even in pure water.

The decomposition of eggs is due to the entrance of putrefactive germs through the porous shell, so that eggs are preserved by closing the pores in various ways. This may be done by smearing with butter, lard, gum, &c., and then covering with saw-dust. Another method is to steep the eggs in saturated lime-water; the solution gradually deposits lime on the shell, and thus closes the pores while increasing its thickness. An objection to this method is that some of the

lime-water penetrates at first and makes the albumen more fluid, giving also a peculiar taste to the egg. The method of desiccation has been tried, but as yet has not been very successful; the yolk especially is difficult to keep. It is said that desiccated eggs will keep if ground up with flour, ground rice, or other farinaceous material; and since eggs are deficient in carbohydrates, this would seem to be a good way of adjusting the balance.

From the land of the wooden nutmeg there comes the artificial egg, for which, however, something may be claimed as a food. They are built up in sections, beginning with the yolk, to make which butter and albumen are mixed in proper proportions and coloured with annatto, then whirled to give the necessary ovoid form. The mass is then frozen and coated with fine gelatin to imitate the limiting membrane, as well as to retain the yolk in shape; then it is coated with a solution of albumen in water till the proper thickness is attained, when it is again rotated, frozen, and coated with gelatin. The whole is coated with sulphate, not carbonate, of lime to form the shell, thicker than a natural shell and non-porous. They are said to be very nutritious (?) and keep for years.

	Bird's Custard Powder.	Goodall's Custard Powder.	Goodall's Egg-powder.	Borwick's Egg-powder.	Yeatman's Egg-powder.	'Model' Egg-powder.	Horsford's Baking-powder.	Average Hen's Egg.
Starch, ...	86·25	84·45	51·03	26·38	52·32	53·82	33·78	—
Albuminous compounds, ..	0·59	0·58	6·01	2·96	6·00	5·06	—	45 grs.
Soluble colouring matter, ..	0·88	0·90	—	—	—	—	—	—
Baking-soda, ..	—	—	15·33	50·70	22·11	26·71	28·02	—
Tartaric acid, ..	—	—	13·69	10·33	11·37	6·19	—	—
Phosphates, ..	—	—	0·24	—	—	—	8·93 (Lime phosphate)	shell, 20 grs.
Carbonates of lime and magnesia,	—	—	2·70	—	—	—	22·70 (Phosphoric acid)	—
Chlorides and sulphates, ...	—	—	—	—	—	traces	Carbonic acid available	—
Water, ...	11·83	13·69	11·00	9·63	8·20	8·22	13·70	135 grs.
Ash, ...	0·45	0·38	—	—	—	—	—	—
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	200 grs.

To meet the popular misconception of the use of eggs in baking, a number of so-called "**egg-powders**" have been offered to a confiding public. Most of these are baking-

powders, consisting of starch and baking-soda, and the "lightness" they confer is due to the disengagement of carbonic acid gas from the baking-soda. The table on p. 142, compiled from various analyses in *Food and Sanitation*, shows at a glance the misleading nature of the names given to these articles. As the comparison with a hen's egg shows, to call these "egg-powders" is simply an abuse of terms, if not worse. An egg contains fully 22 per cent of albuminous matter, while the best of these mixtures contains no more than 6 per cent, and even in this the albumen is mostly of vegetable origin. Judged by this standard, instead of one packet being equivalent to four eggs, as is claimed, it would require *seven* ounce-packets of "Model" egg-powder, or *twenty-five* ½-ounce packets of Borwick's baking-powder. Horsford's, an American preparation, is a good baking-powder, and is sold as such; it differs from the usual domestic combination in substituting phosphoric for tartaric acid, and is thus rich in salts, while the amount of carbonic acid gas for "raising" purposes is considerable.

SUMMARY.

1. Eggs form a perfect food for an embryo chick, and for this purpose the shell is partly utilized.
2. White of egg is albumen and water; yolk contains also fats, as well as sulphur, iron, and phosphorus.
3. Eggs are thus deficient in carbohydrates and salts, deficiencies generally supplied by other articles.
4. Decomposition of eggs is due to the entrance of germs from the air, and may be arrested by closing the pores of the shell in any way.
5. "Egg-powders" are, for the most part, simply baking-powders, entirely innocent of egg substances.

Lesson 28.—ANIMAL FOOD.

The term "animal food" is popularly used to denote the flesh of animals used as food, since even vegetarians permit the use of eggs and milk. **Animal flesh** is muscle, with the several tissues accompanying it, such as connective tissue, fat, and the nerves and blood-vessels supplying the muscle. It

contains therefore the ordinary constituents of muscle, but the proportions will be greatly altered by the amount of fat present, and also if the blood has been drained off or retained. About three-fourths of flesh consists of water, only one-fourth being solids, and those chiefly proteids, for the most part insoluble in water. In living muscle the soluble proteid is in the form of muscle-albumen or *myosin*; but after death there sets in the "death-stiffening" or rigor mortis, a coagulation of the muscle-albumen due to the development of lactic acid, and when the flesh has passed through this stage its albumen is in the state of *syntonin* or acid-albumen. When this rigor mortis is over, the flesh begins to decompose, at first slowly, and this incipient decomposition makes it more tender and better flavoured for a short time. In the case of "wild" flesh, game for instance, where the muscles are very firm and hard, the meat is often "hung" till the parts become tender by advancing decomposition. Since meat is rarely eaten until rigor mortis has passed off, it is thus syntonin and not myosin that enters into food, and the various processes of cooking aim generally at further coagulating the syntonin by the aid of heat. Besides being converted into syntonin by acids, myosin may be converted into alkali-albumen by alkalies, but this is a change which rarely occurs in cookery. It is also soluble in salt solution to the extent of one-tenth, a fact of some importance in connection with the pickling of meat. Besides myosin, animal flesh contains about 2 per cent of serum-albumen derived from the blood in it, and this can be extracted by cold water, though coagulated by heat. The colouring matter of meat is chiefly derived from the hæmatin of the blood, and can be washed out by water. The foregoing, with some other substances amounting to about 5 or 6 per cent, constitute the soluble albuminous matters, and this represents therefore the maximum strength of an aqueous extract like beef-tea; the remaining 14 or 15 per cent of proteids are insoluble in water, though dissolved by the digestive juices.

The table on p. 145 will give some idea of the relative proportions of these substances as found in various classes of meat. From these figures it will be seen that the amount of fat may vary considerably, and that the water and nitrogenous materials are very much reduced in fat meat. Fat meat contains a greater store of energy than lean, but it is neither palatable nor easy of digestion, except by people who have to work under severe climatic conditions.

		Fresh Meat, Lean (Parkes).	Lean Beef (Pavy).	Fat Beef.
Water, ...		73·4	72·0	51·0
Nitrogenous.	Soluble albumen and hæmatin, ...	2·25	19·3	14·8
	Insoluble albumen, ...	15·2		
	Gelatinous substances,	3·3		
	Extractives, ...	1·38		
	Keratin, ...	·068		
Ash, ...		1·6	Fats, 3·6	29·4
			Salts, 5·1	4·4

The composition of meat is affected by various factors, such as the age of the animal, sex, breed, condition, feeding, &c. In young animals the muscles are not fully formed, and are more watery, so that young meat may lose from $\frac{1}{2}$ to $\frac{3}{4}$ of its weight in cooking; the syntonin or muscle-albumen is replaced by gelatine-forming substances, and the fat and salts are also diminished in amount. These defects are exemplified by veal, the use of which may lead to disturbance of the digestive system unless the animal has been "fed" for some time, and even then it is wanting in flavour and nourishing properties, though owing to the prevalence of immature proteids, forming gelatine on boiling, it is well suited for soups. The best beef is obtained from a four-year-old ox, and the best mutton from three-year-old sheep. The flesh of the female is always more delicate than that of the male, and especially at the breeding season the flesh of the latter is apt to be coarse and rank, so that animals bred for feeding have their flesh improved in flavour by early removal of the sexual organs. All animals used as food are vegetable feeders, with the exception of the pig, which may be called omnivorous, though never better than when restricted to its proper vegetable diet, and in many cases the flavour of the several feeding-stuffs is imparted to the flesh. The quantity of meat is greatly influenced by breed, and the condition and general health of the animal, as well as by the particular part from which the cut is made; thus the flank contains 43 per cent of water, but the round of beef 60 per cent.

It is customary to drain off **blood** as much as possible before sending out a carcass, and this is carried to excess in the case of veal, when the calf is bled to death. The effects of remov-

ing the blood are to make the flesh paler in colour and give it a more delicate flavour.

Since blood is a very unstable compound, its removal renders the meat less liable to decay, and since it is also the chief vehicle for the spread of disease germs through the body, its removal lessens any danger on that score. By Jewish law—and the Mosaic law is far in advance of the nineteenth century in sanitation—all the blood was to be drained off, and the Jews of to-day are certainly remarkable for their immunity from such diseases as tuberculosis and cancer, which might be communicated by the blood. The only argument in favour of retaining the blood is to be found in the nutritive qualities of blood itself; but though more nutritive, red meat is less digestible than white, and it is always white flesh in the form of fish, chicken, &c., which is prescribed for invalids.

The **characteristics of good meat** are given by Parkes as follows:—The flesh should be firm, elastic, of a bright uniform colour; in fresh meat the outside is lighter than the inside, owing to oxidation of the hæmoglobin in the blood. Lean meat is paler than blood, so that a dark-purple colour shows that the blood has not been properly drained away, and fresh meat placed on a plate should always part with a slight amount of reddish juice. The flesh of young animals is always paler than that of the mature animal. The muscle should be fine-grained, have a slight pleasant odour, becoming savoury when heated; the flesh should present a marbled appearance, owing to an admixture of fat with the muscular fibres. On cutting, the interior should show no softening of the connective tissue, as this indicates the commencement of decay. The "knife-blade" test is easily applied: push a clean knife-blade in to the bone, and any internal softening will be detected by lessened resistance, and the smell of the blade will reveal decay.

The fat should be healthy-looking, free from bleeding, and firm, not jelly-like in texture; its colour varies from straw-white to pale-yellow, being whiter in young animals. The fat should not be too yellow, though a deep-yellow fat in otherwise healthy flesh may be traceable to feeding with oil-cake. The state of the marrow is often a good test of the condition of meat. It should be light rosy-red in colour, and in the hind-legs solid and firm twenty-four hours after death, while in the fore-legs it is rather softer, like honey.

Of all animal foods **Beef** stands first, both in point of consumption and in respect of nutritive qualities. It is at its best when got from an ox four or five years old, and besides being affected by the factors already mentioned, varies in quality according to the part of the animal used. The best parts are the rump, sirloin, and fore-ribs; buttock, mid-ribs, and part of the shoulder; then the flank, certain parts of the shoulder, and brisket; lastly, the cheek, neck, and shin.

Ox-fat is softer than mutton-fat, because it contains more olein, the olein amounting to one-third of the combined stearin and palmitin. Its melting-point is low, 41–50° C. The following figures show how the distribution of the proximate principles is affected by the cut:—

Very Fat Ox.	Water.	Proteids.	Fat.
Neck, ...	73·5	19·5	5·8
Loin, ...	63·4	18·8	16·7
Shoulder, ...	50·5	14·5	34·0
Hind-quarters, lean, ...	55·01	20·81	23·32
Do. streaky,...	47·99	15·93	35·33
Fore-quarters, lean, ...	65·45	19·94	19·97
Do. streaky,...	32·49	10·87	56·11
Average, ...	54·76	16·93	27·23
Moderately fat ox, ...	72·25	21·39	5·19
Lean ox, ...	76·61	20·61	1·50

Since **Veal** is to a large extent immature flesh it is much less nutritious than beef, and contains more gelatinous and fewer albuminous substances. Its fibres are softer, rendering it easier of digestion by invalids. As a food, it is deficient in fat, but this is generally rectified by serving it with ham or similar fatty foods.

The British practice of killing veal is reprehensible upon two grounds: the calves are killed too young to begin with, and the exhaustive bleeding deprives the flesh of a good deal of the salts in the blood, which have thus to be replaced in cooking by the use of gravy or extracts of meat. "Prepared" veal, as given in the Munich hospitals, where dietetics is reduced to an exact science, is veal minced and cooked with oatmeal. This supplies not only the necessary fat, but also a quantity of carbohydrates, and so forms an all-round food.

The following figures show the composition of different cuts of veal:—

	Water.	Proteids.	Fat.
Lean veal, ...	78·82	19·76	0·82
Fat veal, ...	72·31	18·88	7·41
Loin, ...	76·25	15·12	7·12
Ribs, ...	72·66	20·57	5·12
Shoulder, ...	76·57	18·10	3·62
Leg, ...	70·30	18·87	9·25

Mutton, the flesh of the sheep, is usually much fatter than beef, and its fat is hard and solid, owing to the greater proportion of stearin. On this account it often disagrees with those of delicate stomachs, and is apt to be tallowy in flavour; indeed, tallow is simply impure mutton-fat. The muscle fibres of mutton are shorter and more tender than those of beef, so that mutton is more readily digested. The various cuts of mutton show a wide range in flavour as well as in composition. The following figures are given by König:—

	Water.	Proteids.	Fat.
Moderately fat, ...	75·99	18·11	5·77
Very fat, ...	47·91	14·80	36·39
Hind-quarters, ...	41·97	14·39	43·47
Breast, ...	41·39	15·45	42·07
Shoulder	60·38	14·57	23·62

Of the different breeds of sheep the black-faced stand first for sweetness of flavour, then come the South Down, Portland, &c.

Lamb greatly exceeds mutton in its proportion of fat, and is correspondingly less digestible. To counteract the excess of fat, lamb is usually eaten with acid sauces, pickles, &c. The flesh is more watery than that of the fully-formed animal, but should be firm, whitish in colour, and clear. Lamb does not keep long after being killed.

Goat's flesh resembles mutton, but wants the pleasant flavour and is not so easily digested.

Venison, the flesh of the deer, resembles game in being very short in the fibre, containing little fat, and therefore very

digestible. It is exceedingly savoury, but rather stimulating and highly flavoured for persons of weak digestion. Young venison is very tender and rich in albumen, containing less gelatinous substances than is usual in young flesh. The composition of venison is: water, 74·63; proteids, 19·24; fat, 1·3 per cent.

Hare, when young, is very tender, and possesses an excellent flavour. Its fibres are short, and the flesh is very digestible, nearly as much so as chicken, while it is more stimulating.

Rabbits are not so digestible as hare, except when young. Unless when boiled, they become hard and dry in cooking, and are therefore best served in pie, with extra fat in the shape of bacon. Rabbits may be boiled, when a good deal of the nutriment may be recovered as soup, or they may be stewed and served up with rice, to supply the deficiency of carbohydrates, with a little curry as condiment.

Pork.—The pig, though properly a vegetable feeder, and never better than when exclusively so, is a most miscellaneous feeder, often on very questionable materials, and hence pork, more than any other animal food, is responsible for the introduction of parasites into the human body. Pigs fed on flesh are easily recognized by the strong odour of their flesh, and the soft, jelly-like fat, almost diseased in appearance. When fed on fish, as is often the case in a fishing town, the fishy flavour is distinctly observable in the bacon. The fat of pork is soft, consisting chiefly of palmitin and olein, with little or no stearin; it is large in amount, and therefore of all flesh-meats pork is the most difficult to digest. The varieties in composition due to the condition of the animal are given thus:—

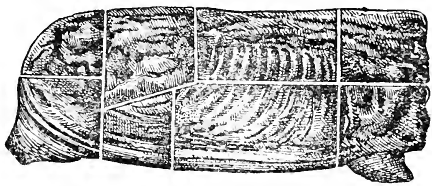


Fig. 34.

Fat Pork, ...	Water, 47·40	Proteid, 14·54	Fat, 37·34
Lean, ...	72·57	19·91	6·81

In the form of bacon it is more digestible, and as such it is used with lean meats, such as chicken and rabbit, or with other

substances rich in nitrogenous matter, such as eggs, peas, beans. Bacon is very nutritious, bulk for bulk, since it contains but little water; its use in times of extra exertion has been already mentioned in connection with the German army. The various cuts of pork are shown in the diagram on p. 149.

The **Tongue** of animals, especially the ox, sheep, and pig, is eaten both fresh and pickled. It is very tender, but contains much fat, especially at the base, the fat being firm and hard like that of mutton.

The varieties of flesh already mentioned have all been of the nature of voluntary or ordinary muscular tissue, but there are also used for food organs consisting chiefly of involuntary or unstriped muscle. **Heart** occupies an intermediate position, and its fibres, though not under the control of the will, resemble the ordinary striped variety. As is to be expected from the nature of its functions, heart-muscle is very close and firm in texture, and therefore not so easy of digestion. Sheep's and lambs' hearts are tender enough, especially if boiled, but bullocks' hearts are generally stuffed with vegetables, so as to make them more juicy and agreeable to the palate.

As an example of pure involuntary muscle, **Tripe** may be taken. This is the paunch of the ox, sheep, or other ruminant animal, and the mucous lining is scraped off, leaving the connective tissue, fat, and involuntary muscle. The latter is very easy of digestion, and the large proportion of fat in it makes tripe altogether one of the most nutritive diets, and specially suitable for invalids. It is best prepared as a soup, and if found too heavy, some of the fat may be removed by skimming. The average composition of tripe is as follows:—Water, 68; proteids, 13·2; fat, 16·4; salts, 2·4.

Another part of the digestive system which vies with tripe in digestibility, lying on the stomach for only an hour, and specially suitable for invalids, is the **Pancreas** or *Sweetbread*. Its readiness of digestion is doubtless partly due to the digestive ferments contained within the gland, so that it is practically self-digesting.

The sweetbread of the throat is the **Thymus** gland, which in the adult human being is represented by a mass of fatty tissue lying at the base of the heart.

The **Liver** is also largely used, especially that of the calf, sheep, lamb, and pig, and to a less extent of the ox. It is difficult to digest, owing to its close texture and rich composition. From what has been said about the functions of the

liver, it will readily be understood that liver will be most profitable when eaten along with some fatty food, such as bacon. The average composition of calf-liver is given as follows:—

Water, ...	72·33	Glycogen and Sugar,	0·45
Proteids,... ...	20·10	Salts, ...	1·54
Fat, ...	5·58		

Kidneys, like liver, are very firm and close in texture, and are therefore difficult of digestion, and the difficulty is increased by over-cooking, since the kidney in that case becomes an indigestible leathery mass. Sheep's kidney contains 17 per cent of proteids and 2 per cent of fat.

The use of **Blood** as a food was forbidden to Noah and his descendants, *i.e.* to the whole human race, and modern taste, though far from being subservient to the Scriptures, has approved the verdict. The only blood used for food is pig's blood in the familiar "black pudding", and even that is rather a pudding of groats, enriched with fat and seasoned and coloured with blood.

The **Brains** of animals are used as food on the Continent. They are very watery, rich in fat, and therefore not very easily assimilated.

A more useful source of food is **Bones**. All the connective tissues, including bone and cartilage, yield varieties of gelatine on boiling, and though gelatine is not so easily assimilated as albumen, say only to the extent of one-third as much, still the amount of gelatine obtained from bones furnishes a food-supply not to be despised, and specially useful in soup-making. 3 lbs. of bone contain as much carbon as 1 lb. of meat, and as much nitrogen as 7 lbs. of meat. To get the maximum amount of gelatine the bones are broken up into small pieces, and digested at 150° C.; best in a digester or high-pressure pot. Gelatine is very soluble in hot water, and sets to a jelly on cooking; it forms the basis of the several varieties of potted meats.

Poultry and Game are characterized by short muscular fibre, a small amount of fat, and a large amount of phosphates in the ash. Birds like the common fowl, guinea-fowl, and turkey, which give a white flesh, are the most easy of digestion, being tender and of a delicate flavour. A young well-fed chicken is the most digestible of all animal foods, but it is apt to pall on the taste after a while, and so is taken occasion-

ally with meat rather than by itself. The short-legged fowls are more delicate in flavour, and as for age, a cock of even one year will be found to be too tough for most purposes, except stewing for soup or in a pie. A young cock is known by its smooth legs, a young hen by its swelling breast. The flavour and tenderness of the flesh, as well as the size of the bird, is greatly increased by removal of the sexual organs.

Ducks and Geese have more fat, are richer in nutriment and stronger in flavour than fowls. Their flesh is darker in colour, and is more difficult of digestion.

Among **Game**, *Partridges* and *Pheasants* when young are very delicate in flavour; *Pigeons* less so. Purely wild birds, such as *Grouse*, &c., are very firm and close in fibre, and on that account are generally "hung", to impart tenderness and develop flavour. They are not so fat as poultry, are rich in proteid matter, and therefore not so suitable for persons of weak digestion, owing to their strong flavour, often fishy, derived from the food of the birds; the best portion is the breast.

SUMMARY.

1. Animal flesh consists of 75 per cent of water and about 20 per cent of proteids, with a varying amount of fat.

2. The chief proteid in meat is muscle-albumen in the form of syntonin or acid-albumen, along with some serum-albumen and extractives.

3. Quality of meat depends upon various factors:—Age, sex, breed, feeding, condition, and health of the animal, as well as the particular "cut".

4. Generally speaking, the shorter in fibre and leaner meat is, the more easily is it digested.

Lesson 29.—FISH.

Fish as a food-stuff contains a large proportion of water, a varying amount of fat, and nitrogenous matters chiefly of the gelatine-forming order. Isinglass, the finest form of gelatine, is obtained from fish bones, but more especially from the sounds of cartilaginous fishes, such as the ray and sturgeon. The flesh of several fish is affected in smell and flavour by the feeding, and a too exclusively fish diet is said to cause affec-

tions of the skin and to predispose to leprosy. Fish is not so satisfying or so stimulating as animal flesh in general; it is readily digestible, and therefore very suitable for persons of feeble digestion, with whom the golden rule at meals should be "small and often". On account of the large amount of phosphorus contained in fish, it has been vaunted as a brain food, but this is simply owing to the fact that since fish is so easy of digestion, it is admirably suited to persons of sedentary habits. It is said to produce aphrodisiac effects.

Fish are at their best just before spawning, when they are said to be **in season**; after that they become poor and flabby. Immature fish are, of course, always in season.

By the Freshwater Fisheries Act of 1878 a close time exists from March 15 to June 15, for all freshwater fish except eels, pollan, trout, and char. The scheme on p. 154 shows when to buy fish, a black line showing when fish are in season.

Fresh-water fish are best when taken from deep water with a rocky or stony bottom, and it is this which gives the pre-eminence to the fish of Alpine lakes. Sea fish, also, are best when caught off rocks in currents of deep water; those caught in shallow and sheltered places are poorer in flavour. Short and thick fish are to be preferred to long narrow ones; those without scales are unwholesome and indigestible, and were prohibited under the Mosaic law. They decay readily, and cannot be cooked too fresh; the perfection of fish-cooking is obtained when the fish is transferred immediately from the water to the kettle, and, if from the sea, boiled in sea-water. Keeping in ice deteriorates their flavour. An exception must be made in favour of the cartilaginous fishes, such as ray and sturgeon, which improve by keeping, since the muscular fibres become more tender, as in game when "hung". When smoked, salted, or pickled, fish are much less digestible than when fresh, and in this state they are better avoided by dyspeptics. The best suited for smoking or otherwise preserving are firm oily fish, like the salmon and herring.

In choosing fish, the following are the main indications of freshness:—The flesh is stiff and firm, the animal being in a state of rigour; the scales do not come off easily; and, above all, the eyes and gills are bright, while the tail is firm and not drooping. Cod, haddock, and whiting keep best; flat-fish keep better than herrings or mackerel.

The most profitable and wholesome method of cooking fish is by boiling, or still better by steaming, as in boiling their

Fish.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Bloater, ...	—	—	—						—	—	—	—
Brill, ...	—	—	—						—	—	—	—
Cod, ...	—	—								—	—	—
Crabs, ...				—	—	—	—	—	—			
Dory, ...		—	—	—	—	—	—	—	—	—	—	—
Eels, ...	—	—				—	—	—	—	—	—	—
Flounder,		—	—	—			—	—	—	—		
Grayling, ...								—	—	—	—	—
Gurnard, ...	—	—							—	—	—	—
Haddock, ...	—							—	—	—	—	—
Hake, ...	—						—	—	—	—	—	—
Halibut, ...	—	—	—							—	—	—
Herring, ...					- -	—	—	—	—	—	—	—
Ling, ...	—	—	—	—							—	—
Lobster, ...		—	—	—	—	—	—	—	—	—		
Mackerel,	—	—	—	—	—	—				—	—	—
Mullet, gray,							—	—	—	—		
Mullet, red,				—	—	—	—	—	—	—		
Mussels, ...	—	—	—	—								—
Oyster, ...	—	—	—	—					—	—	—	—
Pike, ...	—	—								- -	—	—
Plaice, ...	—	—	—	—						—	—	—
Prawns, ...		—	—	—	—	—	—	—	—	—	—	
Salmon, ..		—	—	—	—	—	—	—	—			
Scallops, ...	—	—	—	—	—	—						
Shad, ...		—	—	—	—	—	—	—	—			
Skate, ...	—	—	—	—							—	—
Smelts, ...	—	—	—	—						—	—	—
Sole, ...	—	—				—	—	—	—	—	—	—
Sprats, ...	—	—	—								—	—
Sturgeon, ...				—	—	—	—	—				
Trout, ...		—	—	—	—	—	—	—				
Trout, sea,				—	—							
Turbot, ...	—	—	—	—						—	—	—
Whitebait,	—	—	—	—	—	—	—	—				
Whiting, ...	—	—	—	—					—	—	—	—

fibres tend to fall asunder, and a good deal of substance is extracted by the water. The addition of vinegar to the water has a good effect, not only converting the proteid matter into acid-albumen, but dissolving many of the small bones. This is well seen in the use of potted herring, when the small bones may be completely dissolved, and the whole fish almost thus utilized as food. They may also be baked, but frying in the dry way is the most objectionable method, since the flesh is rendered more indigestible; fried skin should not be eaten except by those whose digestion is good.

Fish may be classified as white or oily, according as their fat is confined to the liver or distributed throughout the body. Under the former head will be comprised whiting, sole, turbot, brill, cod, haddock, plaice, flounder, dab, &c.; while oil fishes include the salmon, a "red" fish, the eel, pilchard, sprat, sardine, herring, and mackerel. The composition of a few representative fish is shown in the following table (Parkes):—

	Salmon.	Herring.	Sole.	Mackerel.	Eel.	White Fish.
Water, ...	77·00	80·71	86·14	68·70	75·00	78·00
Proteids, ...	16·10	10·11	11·94	23·50	9·90	18·10
Fat, ...	5·50	7·11	0·25	6·76	13·80	2·90

Among **white fish** the *Whiting* is the chicken of the sea, very light, easily digested, and when fresh possessing a delicate flavour. The *Cod* is very subject to parasites, and its use was prohibited to the Jews. It varies very much in quality, being sometimes hard and tough; when it is at its best there will be found between the flakes of flesh coagulated albumen on boiling. *Haddocks* are offered both fresh and in various stages of preservation, Finnan or Eyemouth, Bervies, Aberdeens, and "close fish". The *Turbot* is richer than the sole, and has a finer flavour. It is firmer in texture, and improves by being kept a short time. *Brill* resembles turbot, but the flavour is inferior.

Among **oily fish** *Salmon*, the only red fish, is rich in fat, which is most abundant in the belly. Its flesh is too rich for most people on accout of the oil in it, and requires a corrective in the way of vinegar or other acid sauces. The most nourishing of oily fishes is the *Eel*, which is exceptionally rich in fat, the proportion of this being about double that of the proteids. Although oily, it possesses the advantage of being readily digestible as well as delicate in flavour, and it has always been a favourite invalid dish. Like cod and shell-fish, it was prohibited by the Mosaic law. *Mackerel* readily taints, and must therefore be cooked very fresh. There are two seasons for catching mackerel, in spring and in autumn; the former furnishes the larger catch, but the autumn fish are finer. Of all the oily fishes the *Herring* takes the first place in point of commercial importance. On account of its large amount of fat it is either boiled or fried with oatmeal, and eaten with potatoes or similar carbohydrate material. Choice fresh Loch-

fyne herrings are dignified with the name "Glasgow magistrates". When smoked for an hour or two they are called "bloaters", and this is the most profitable form of cured herring. As the smoking continues they become successively kippers, red herring, and even black herring. The great majority of the herring caught are made into red herring; black herring are chiefly exported to Roman Catholic countries.

Roe is rather a delicacy than a food, and is used either fresh or salted, and pickled in various ways. The hard roe is the ovary, the soft roe or milt is the spermatic organ of the male. Caviare is salted sturgeon's roe.

The *sound* is the swimming-bladder, and that of the cod is occasionally used as food. The best kind of isinglass is prepared from the lining membrane of sturgeon's sound.

Shell-fish consumed as food belong to the two natural divisions of crustaceans and molluscs, and are chiefly marine forms. They are all prohibited by Jewish law. The Crustacea are represented by the lobster, crab, crayfish, shrimp, and prawn. They are very nutritious, but at the same time highly indigestible, and tend to induce skin disorders, such as nettle-rash, more especially in gouty and rheumatic subjects, in whom metabolism is not so thorough as usual. All shell-fish should be eaten *very fresh*, as they decompose rapidly, developing poisonous products in the process; lobsters and crabs especially may give rise to diarrhœa and vomiting accompanied by giddiness and nausea. As a rule, the Crustacea are foul feeders, and this constitutes another source of danger to the consumer.

Among the **Crustacea** the *Lobster* is more delicate and digestible than the crab, and the flesh of the claws is better than that of the tail. It decomposes rapidly, especially in hot weather, but this is to a large extent obviated by keeping the animals alive in the shops, and, indeed, until cooking. The bright-red part within the animal's body is the ovary. Lobster spawn is very nutritious, and is often worked into sauces for the sake of its flavour and colour. The *Crab* is altogether inferior to the lobster. Its flesh is tougher, and consequently harder to digest. The liver is the soft part inside the shell, and is the most nutritious part of the animal, though heavier on account of the fat it contains. The *Crawfish* or *Crayfish*, a fresh-water species, is more delicate than lobster, and is preferred to it, especially in Paris, to which great quantities come from the river Meuse. It is supposed to be more digestible when eaten hot, and it enters into the composition of bisque soup. The *Sea Crawfish*

or Spring Lobster resembles the lobster in flavour. The smaller crustaceans, such as *Shrimps* and *Prawns*, are rather to be regarded as stimulants than as food, though the circumstance that the shells are also eaten in whole or part, adds a good deal of mineral matter to the body in the form of magnesia and lime carbonates. They are best cooked in sea-water, and when taken as an occasional treat have a distinct appetizing effect.

Mollusca are represented by the oyster, mussel, whelk, periwinkle, cockle, and other marine forms, as well as the terrestrial snails so largely used in France. Of all the molluscs the *Oyster* takes the first place, and the small "natives" are the finest in flavour. When fresh and raw it is very digestible, but cooking converts it into an indigestible leathery mass. The hard muscle which closes the shell is much firmer and proportionately more difficult to digest than the soft part which forms the bulk of the animal. This latter is the liver, and in eating oysters raw the liver ferment is allowed to act upon the glycogen stored within that organ, so that the oyster is in a sense self-digested. The composition of oysters is given as follows: Water, 89·69; proteids, 4·95; fat, 0·37; extractives, 2·62. As these figures show, the value of oysters as a food is extremely small; in order to get the required daily allowance of nitrogen —300 grains—one would have to take ten dozen oysters daily. They are only in season in the months containing an "r". The *Mussel* is a very succulent shell-fish, and when cooked in sea-water with a little vinegar is a dainty enough dish; but it is a very foul feeder, often flourishing in sewage-contaminated waters, and unfortunately it is out of season at the very time when the cities strew their inhabitants by tens of thousands along the coast. The mussel has an evil reputation for poisonous qualities, and there has been obtained from it a poison of the nature of a ptomaine, called mytilotoxin, and this exists in the liver, more especially in the summer months, May to September, the very time when mussels are eaten indiscriminately. Bacteria of various kinds have also been found in the liver. Two well-marked cases of mussel-poisoning are recorded in the *British Medical Journal*, the Liverpool case of September, 1888, and the Dublin case, July, 1890.

In London district the *Whelk* is largely used, especially among the poorer classes. In the south of England these are obtained by dredging, but the Galloway whelks are caught by fish-bait. They were more highly esteemed in the middle ages than now; 8000 whelks formed part of a feast given by

the Archbishop of Canterbury in 1504. Like mussels, they are boiled, preferably in sea-water, and served with vinegar and pepper. In Scotland whelks go by the name of Buckies, and the animal called there Wulk or Wilk is the English *Periwinkle.* This is by far the most pleasant of all the molluscs, and it is also the most common, London alone consuming annually 1900 tons, worth £15,000. They are boiled in their shells in natural sea-water, or in water to which salt has been added. *Limpets,* with *Cockles* and other bivalves, are more muscular than the foregoing, and are more nutritious but less digestible in consequence.

The only terrestrial univalve is the *Escargot* or vineyard snail. Its use is confined to France, where it is called the poor man's oyster. They grow in the vineyards of Champagne and Burgundy, and are best when bred on well-drained clean land. They are vegetable feeders, their chief food being poisonous Solanaceous plants, the same order to which belong potatoes and the common nightshade. These are, therefore, best after the winter, when they are fasting, and in any case are kept a day or two before use to allow the removal of any hurtful substances. Their flesh is highly nitrogenous, but cooking makes it hard and firm, not so readily digested, and somewhat tasteless.

SUMMARY.

1. Fish forms a nutritive diet, more watery than meat, but more digestible, and, like it, deficient entirely in carbohydrates.

2. Its proteids contain more gelatine-formers, and there is a greater loss in boiling, owing to the amount of extractives.

3. White fish have their fat confined to the liver, and are more easy of digestion than oily fish, which have their fat generally diffused.

4. Mature fish should only be eaten when in season, and as fresh as possible.

5. Shell-fish of all kinds should be used with discrimination, only when in season, obtained from pure waters and very fresh, and even then as an appetizer rather than a food.

LESSON 30.—VEGETABLE FOODS.

Plants contain all the proximate principles found in animal food, but in very different proportions and qualities, being as a rule poor in fats and very rich in carbohydrates, while their

albumen differs largely from animal albumen. **Vegetable proteid** matters appear under the forms of—(1) *Vegetable albumen*, not unlike egg-albumen, and coagulated by heat; (2) *Legumin*, sometimes called vegetable casein, because, like the latter, it is coagulated by rennet and acids, but not by heat; (3) the *Glutin* class of bodies, comprising glutin-casein, glutin-fibrin, gliadin, and mucedin; and (4) other nitrogenous substances, such as asparagin, which are useless as food.

Taken in all, vegetable proteid matter is less digestible and less easy to assimilate than animal proteid. When rich, as in beans and peas, the presence in it of a large amount of sulphur leads to flatulence, owing to the formation of sulphuretted hydrogen and other sulphur compounds.

Vegetables are poor in fats, oats and maize heading the list in respect of fat. Cocoa-nut oil, palm-oil, and cacao-butter are examples of solid **vegetable fats**, but only the last is commonly used as food; while the liquid fats are represented by olive-oil and its adulterant cotton-seed oil, as well as almond-oil, which constitutes 50 per cent of the sweet almond often used in pastry and sweetmeats. Vegetable oils are often classed for commercial purposes as drying and non-drying oils, the former being distinguished by the fact that on exposure to air they absorb oxygen and become dry and solid. The most important drying oils are those of linseed, hemp, walnut, and poppy, the last being the most palatable; while castor-oil, which gradually hardens on long exposure, forms a link between the two classes. The non-drying oils, including olive-oil and cotton-seed oil, are those chiefly used as food.

In addition to these, which are obtained by pressure, most plants contain volatile or **essential oils**, to which they owe their fragrance. They are called volatile, because while staining paper like any oil the stain disappears, as would happen in the case of a substance like benzene. These essential oils are diffused through every part of the plant, but are concentrated in certain parts; thus in the orange, lemon, &c., they may be found in the rind; in the rose tribe they reside chiefly in the petals; in umbelliferæ chiefly in the seeds; and so on. Though mainly used in perfumery, they enter largely into dishes or flavourings, and act as condiments to excite the appetite and stimulate the several digestive juices.

Carbohydrates form the great bulk of vegetable foods, and are represented by starch, cellulose, and sugar. The general properties of these have already been described in lesson 8,

and need little further comment. The different farinaceous or starchy foods are recognized under the microscope by the appearance of the starch grains, whether even in contour or facetted; to the latter class belong the starches of oats, maize, and rice. Accompanying starch, and often formed from it in cooking, is dextrin, recognized by its solubility and yellowish colour. In ripe fruits dextrose and other sugars are found, formed at the expense of cellulose and starch in the process of ripening. Along with starch may be put other carbohydrates of the same composition, such as Lichenin, found in Iceland-moss, Inulin, Mucin, and the different gums. All plants contain, often in large proportions, cellulose or vegetable fibre, familiar as cotton-wool and paper. When very young it may be digested, but with growth it becomes woody, and is not only itself indigestible, but hinders the digestion of other substances. A small amount of unavoidable cellulose fulfils a useful function as a laxative, by stimulating the mucous membrane of the bowels.

In addition to cane-sugar, obtained chiefly from the sugar-cane, beet, and maple, all plants, and more especially fruits, contain fruit-sugar, dextrose and levulose, various glucosides, pectose or vegetable jelly, and the fruit acids, citric, tartaric, and others, all of which have been already dealt with.

The **salts of plants** are characterized by excess of potash and phosphates, and, in the case of grain, indigestible silica; while in many of the cereals, notably wheat, iron is found in combination with phosphoric acid. In animal foods, on the other hand, soda and chlorides are the predominating salts, so that herbivorous animals require to supplement their vegetable diet by the use of common salt or sodium chloride.

Almost every part of plants furnishes food, but more especially the seeds, roots, and stem. Plants which furnish their seeds as food belong to the two great divisions, cereals or grains, and leguminous plants or pulse. **Cereals**, called after Ceres the goddess of corn, comprise all grain or corn-bearing plants. They are really grasses, which by special cultivation have developed a maximum of food material with a minimum of husk, and they have been cultivated from remote antiquity, the use of millet, lentils, and barley being pre-historic in origin. In geographical distribution they extend over the whole globe, from the equator to within the bounds of the Arctic circle, the extremes being represented by such tropical forms as sorghum and millet, and barley, oats, and rye, which are grown in the

extreme north of Europe, maize having the greatest range of temperature. Their seeds dry easily, and can be stored in granaries or shipped without loss, and the proportion of nutriment to bulk, already large, is increased by storage, owing to loss of water. They contain from 5 to 14 per cent of nitrogenous matters, chiefly in the form of glutin, while the bulk of the grain consists of starch, the whole enclosed in a covering of cellulose often silicated. Owing to peculiarities in the glutin, the only cereals suitable for bread-making are wheat and rye; but all of them can be made into cakes, porridge, or puddings, as well as used in soups.

By the process of grinding, the outer coats of cellulose are first removed, and to obtain a nutritious meal or flour the grinding should be arrested at this stage, since the cells containing glutin lie next the outer surface. The salts in grain, as determined from the ash, depend very largely on the kind of soil and the manure employed, if any. They consist chiefly of phosphates of soda and potash along with lime and magnesia, with a little silica and iron. The following tables will afford materials for a comparison of the different grains with each other, and with the meal or flour derived from them:—

Grain.	Proteids.	Fat.	Digestible Carbohydrates.	Cellulose.	Ash.	Water.
Wheat,	12·42	1·70	67·89	2·66	1·79	13·56
Rye,	11·43	1·71	67·83	2·01	1·77	15·26
Barley,	11·16	2·12	65·51	4·80	2·63	13·78
Oats,	11·73	6·04	55·43	10·83	3·05	12·72
Maize,	10·05	4·76	66·78	2·84	1·69	13·88
Rice,	7·81	0·69	76·40	0·78	1·09	13·23
Millet,	11·3	5·6	67·3		2·3	12·3
Buckwheat,	9·28	1·89	70·68		0·86	14·27
Wheat flour,	8·91	1·11	74·28	0·33	0·51	14·86
Do., coarse,	11·27	1·22	73·65	0·84	0·84	12·18
Rye, fine,	10·21	1·64	73·64	0·64	0·98	13·99
Do., coarse,	11·06	2·09	67·78	2·61	1·69	14·77
Barley-meal,	10·89	1·23	71·85	0·47	0·63	14·83
Pearl-barley,	7·25	1·15	76·19	1·36	1·23	12·82
Oatmeal,	14·29	5·65	65·73	2·24	2·02	10·07
Maize-meal,	14·0	3·80	70·68		0·86	10·60
Ground rice,	7·43	0·89	77·62			14·15

Parkes gives the following "order of merit" of the common grains in respect of proximate principles:—

Proteids.	Fats.	Starch, &c.	Salts.
Wheat.	Oats.	Rice.	Barley.
Barley.	Maize.	Maize.	Oats.
Rye.	Barley.	Wheat.	Wheat.
Oats.	Rye.	Rye.	Rye.
Maize.	Wheat.	Oats.	Maize.
Rice.	Rice.	Barley.	Rice.

Wheat.—The first place among the cereals must be assigned to *Wheat*, of which there are two varieties, summer wheat and winter wheat. König gives the following as the average of 250 different analyses:—

Water, ...	13·56	
Nitrogenous, ...	12·42	Higher in Italian and Russian wheat.
Fat, ...	1·70	Wheat is the most deficient in fat of all the British grains.
Sugar, ...	1·44	Varying from 60 to 90 per cent.
Gum and dextrin,	2·38	
Starch, ...	64·07	
Indigestible fibre,	2·66	
Ash, ...	1·79	Chiefly phosphates of potash and magnesia, with a little lime, soda, and silica.

Russian wheat is richer in nitrogenous matters, ranging up to $21\frac{1}{2}$ per cent. The hard Italian and Hungarian wheats are also rich in nitrogenous matters, containing soluble albumen as gluten. The grain is surrounded by two coats, an outer coat or cuticle and the inner composed of bran cells; underneath this lie the gluten cells containing also fat and salts, while the centre of the grain is occupied by starch cells. Associated with the latter is cerealin, a form of diastase, which helps to render the starch self-digesting. The cuticle and bran cells are removed by grinding, which leaves behind a completely digestible flour, white or yellowish-white in colour and fine in

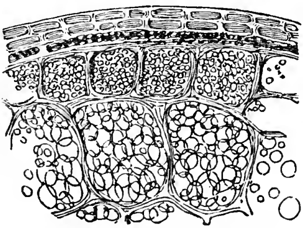


Fig. 35.—Vertical Section of Wheat.

texture. Flour is ground while separated from the bran, and according to the amount of grinding is yellowish-white from the presence of gluten, or pure white, in which case it is likely to contain little except starch. Good flour should have a pleasant smell, and an absence of acid or rancid taste. It should not contain more than 15·2 per cent of water, otherwise it will not keep well. A test of good flour is the amount of water it absorbs, and when spread out it should show no traces of bran. There is always a loss in grinding, 100 parts of wheat giving 80 of flour, 16 of bran, and 4 of loss. The flour itself is classified as best, seconds or middlings, and thirds, bran flour or pollards. A dark-coloured flour indicates often damp, either during harvesting or in storage.

When grinding has been carried to excess so as to produce a fine white flour, not only is part of the gluten removed but a good deal of the fat and salts associated with it, and the product is correspondingly less nutritious, since bran contains 15 per cent of nitrogenous matters, $3\frac{1}{2}$ fat, and 5·7 salts. "Whole" wheaten meal, while more nutritious, is apt to be irritating on account of the indigestible outer coat consisting of cellulose and siliceous matters, and while this is useful as a laxative for persons of sedentary habits its use has not been general. A *via media* has been found in decorticated whole wheaten flour, in which only the two outer layers already mentioned are removed, and when the flour is finely ground any mechanical irritation of the digestive canal is avoided. The grain is also crushed to form wheaten groats, much used in America, and preferred to oats in point of delicacy and digestibility. Of recent years a granular preparation of wheat has become familiar under the name of *Semolina*. In Glasgow semolina is made from American wheat, but the Italian semolina is made from hard Italian wheat rich in gluten, as are also macaroni, vermicelli, and kindred products, which have thus a higher nutritive value than bread.

Like most grains, wheat is subject to parasites, both animal and vegetable. Among the former are mites (Acarus), a sign of commencing decomposition; the common weevil, more frequently found in oats; and the larvæ of a species of moth, called the chocolate moth because it feeds on chocolate. These last have caused great ravages among stores of biscuit on board ship. Vegetable parasites include mildew or red-rust, bunt, and smut; all species of fungi-smut are said to induce diarrhœa.

Wheat and rye are the only cereals suitable for **bread-making**,

and the whole process of bread-making aims at converting the dough into a porous mass. Dough is prepared by kneading together the necessary quantities of flour and warm water, flour 20 lbs., water 8–12 lbs. or $6\frac{1}{2}$ to $9\frac{1}{2}$ pints, and from $1\frac{1}{2}$ to 2 ozs. of salt. The porosity of bread, which distinguishes it from biscuit, is obtained by the disengagement within the mass of carbonic acid gas according to one of three methods.

First, by fermentation. The dough is divided in the proportion of 2 : 1 and the salt added to the larger portion. To the other is added the ferment, consisting of yeast and mashed potatoes, or a "leaven" of dough already fermenting, and the whole is allowed to stand in a warm place to encourage fermentation. When carbonic acid has been produced in sufficient quantity to make the mass spongy, it is kneaded up with the larger portion and again set aside till the whole mass is leavened. Before the spongy mass begins to sink again it is made into loaves and fired in ovens heated on the German principle, *i.e.* by wood fires kindled inside them and swept out at the proper time; in factories the ovens are either heated by hot pipes or are revolving. By this fermentation several changes take place, both mechanical and chemical. If the fermentation has been incomplete the bread is "sad" or heavy, and if carried too far the yeast fermentation is apt to be succeeded by others, such as the lactic fermentation, and this is especially likely to occur if "leaven" be used instead of yeast. The processes are briefly these:—Starch becomes partly changed into dextrin and sugar, and this latter is again partly decomposed into alcohol and carbonic acid. The alcohol seems to be entirely driven off by the heat of the oven, and from the same cause the bread loses water, so that $6\frac{1}{2}$ lbs. of dough give only 6 lbs. of bread. The crust is much caramelized, and contains only 16–27 per cent of water, since it has been exposed to almost boiling heat, 180° F., while the crumb, rarely heated above 38°, contains 20–47 per cent of water. The more water new bread contains the more likely is it to turn mouldy, and of course the less nutritious it is, weight for weight. When bread becomes stale it loses water, but if stale bread be reheated it becomes soft again, not, of course, to the acquisition of more water, but owing to molecular changes in the solid constituents. Since some of the starch becomes sugar, bread always contains more sugar than was baked with it, and the soluble carbohydrates, sugar and dextrin, are thus always in greater proportion than in the original flour. A

little of the alcohol may be converted into acetic acid, and a little of the sugar into lactic and other acids. The nitrogenous matters of the flour, both soluble albumen and gluten, are rendered insoluble and combined more thoroughly than before with the starch, and a little of the nitrogenous substance in the crust is destroyed. It is now held that new bread is more likely to be germ free than stale bread, owing to the germicide action of the heat in baking. From the above statements it appears that yeast has almost a digestive action upon flour, converting starch into dextrin and sugars, chiefly maltose and glucose, and changing proteids into albumoses, or even into peptones, as in the human stomach.

To check fermentation and improve the colour of bread *Alum* is often added; the proportion should not exceed 10 grs. per 4-lb. loaf. Alum is easily detected by shaking up some flour in its own weight of water, and adding fresh logwood solution rendered alkaline by ammonium carbonate; if alum be present the flour will turn lavender in colour instead of pink, and in this way 1 in 10,000 of alum may be detected.

The second method of generating carbonic acid gas is by the use of various baking-powders. The ordinary domestic baking-powder is bicarbonate of soda and tartaric acid, which leaves tartrate of soda in the bread. M'Dougall's and Liebig's baking-powders have acid phosphate of lime, with carbonate of soda or potash and salt; in this case leaving in the bread a phosphate of lime and potash. Neville's process consists in using ammonium carbonate alone, and it has this advantage, that ammonia as well as carbonic acid escapes, leaving no residue. These unfermented or unleavened breads of course contain none of the bye-products of fermentation, but their taste is not so agreeable as that of ordinary bread, and except in household baking they are rarely used.

The third process for "raising" bread is Dauglish's, and consists in passing carbonic acid gas under pressure into the mass of dough. This is entirely done by machinery, and produces what is called Aërated Bread. It is sweeter and drier than ordinary bread, and therefore in keeping does not mould, but rather breaks up, being very brittle. Its flavour differs from that of ordinary bread, and of course there is no chemical action such as occurs when yeast is used.

Biscuit differs from bread in that there is no yeast used in its manufacture. It is made from flour containing as little bran as possible, since bran absorbs water readily, and worked

into a dough with water only as in ordinary ship biscuits, or with butter, milk, sugar, &c., in the case of table biscuits. As the name implies, they are well baked in the process; all their starch is converted into dextrin, so that they assume a yellow colour and are fairly soluble in water. A perfect biscuit melts in the mouth, and many of the better infants' foods consist of little else than biscuit powder. Owing to the greater heat employed in their manufacture, biscuits contain less water than bread, and are therefore more nutritious bulk for bulk, $\frac{3}{4}$ lb. biscuit being equivalent to 1 lb. bread. They also keep well, getting drier and consequently harder, and are thus well adapted for shipment. The disadvantages of biscuits are that, like wheat, they are deficient in fat and salts, and tend to pall on the appetite if eaten too constantly.

When a piece of bread is slowly baked all the starch becomes changed into dextrin, and the piece becomes yellow, forming Rusk biscuit, so much used for children and invalids. The so-called "unleavened bread" of the Jews is merely water biscuit.

SUMMARY.

1. Vegetable foods contain all the proximate principles, but are specially rich in carbohydrates.

2. Vegetable proteid occurs as legumin and gluten-forming substances, and is not so easily digested or assimilated as animal proteid.

3. Vegetables are rich in potash and phosphates; animal food in soda and chlorides.

4. Their carbohydrates are chiefly in the form of starch, sugar, and gums, with often a considerable quantity of indigestible cellulose.

5. The leading plants used as foods are cereals and legumes, the former containing gluten, the latter legumin.

6. Wheat is the most nutritious and digestible of all the cereals, and is the grain chiefly used in making bread.

7. As a rule, gluten cells in a grain lie immediately below the bran, and are therefore liable to be removed by excessive grinding.

8. In making "leavened" or fermented bread, various changes occur, all in the direction of making the bread more easily digested.

9. In using baking-powders, except Neville's, various chemical residues are found in the bread, generally of an aperient nature.

10. Biscuit is an unfermented bread in which all, or nearly all, the starch has been dextrinized.

Lesson 31.—THE CEREALS (*Continued*).

As will be seen by a reference to the table on page 161, **Oats** head the list of cereals in respect of nutriment, especially in the matter of nitrogenous matters and fat, in the latter of which it excels the other cereals. The fat in oats is remarkable as not containing sufficient glycerin to neutralize the fatty acids, oleic, stearic, and palmitic, so that there is some fatty acid free. Their nitrogenous principles amount to 11·73 per cent, and consist chiefly of gliadin and vegetable casein in the form of avenin, a substance resembling legumin in composition but gluten casein in properties. Oat gliadin contains nearly twice as much sulphur as that of wheat. Since the nitrogenous principles of oats do not form gluten on the addition of water, oats have no adhesiveness, and therefore cannot be made into bread. They are, however, readily baked into cakes, and in the forms of porridge and gruel are more readily cooked than either wheat or barley. One drawback to oats is the large amount of cellulose which they contain; this induces a laxative action in many people who are not accustomed to oatcakes or oatmeal porridge, and in others even dyspeptic symptoms occur, but this disappears on continuing the use of the grain. The proportion of ash in oats is large, and, as in most cereals, the ash consists of phosphates of potash, magnesia, and lime, with a high proportion of silica in this case.

When the grain has been deprived of its outer coat it is known as Groats or Grits; when crushed, these form Embden groats, and these, with Quaker oats, Provost oats, similar brands, are becoming increasingly popular. The nutritive qualities of oats are well known. Although Johnson in his dictionary rather slighted oats when he described it as a grain used in Scotland for human food but in England for horses, the reply is obvious and unanswerable: "Where will you get such men, and where such horses?" It has the distinct advantage of consumption for long periods without a feeling of sameness, and the members of many a Scottish family have had porridge night and morning for their whole lifetime. Oats are said to be "heating", but this is not confirmed by those who use them constantly. Oatmeal in water forms a most refreshing drink during hard work, especially in hot weather.

For invalids, especially those suffering from gastric catarrh or other stomach troubles, no more nourishing food can be

supplied than oatmeal jelly. To make it, take a good handful of oatmeal, and add to it in a basin hot water till rather thin, then allow it to stand half an hour. Decant or strain off the supernatant liquid, and boil with a little salt till it forms a jelly on cooling. For very weak patients a dessert-spoonful every half-hour is quite sufficient, and a touch of treacle may be added to keep the bowels open, or the jelly may be flavoured by a little lemon-juice.

Barley resembles wheat closely, but differs from it in having more salts, fat, and cellulose, but less proteid and carbohydrate substances. The proteids resemble those of oats in this respect that they do not form gluten on addition of water, but remain soluble in the state of albumose, albumen, and globulins. On this account it is not made into bread, the so-called barley-bread being made from a mixture of barley-meal and wheaten flour. This bread is said to be rather laxative; it is certainly heavier and less digestible than wheaten bread, and the same may be said of barley-cakes.

The ash of barley is especially rich in phosphates and iron, and on that account barley is often given to children and others in the form of soup or barley jellies. The nutritious character of barley is evidenced by its extensive use in fattening cattle; among the Greeks it formed the staple training food for athletes, while some place barley before all other grains for the purpose of restoring strength. The whole grain is ground to form barley-meal; when stripped of the husk and roughly ground it is called pot-barley, Scotch barley, or milled barley; when the grains are further rounded and polished they form pearl-barley. Pot-barley is more nutritious than pearl-barley, from the fact that the gluten cells are near the surface. In the form of barley-broth and -pudding it forms a common article of diet. Barley-water, made from pearl-barley, is often added to cows' milk in infant feeding instead of lime-water, and with much better results. The process of converting barley into malt will be dealt with in describing alcoholic fermentation.

Rye is not much used in this country except for malting, but in the east of Europe it forms the staple food and affords as much nutriment as wheat. Its proteid substances resemble those of wheat in forming a sort of gluten on adding water, and it can thus be baked into bread. The grain has a peculiar odour and is brown outside, so that rye bread is "black" bread. It is heavy and indigestible, sourish in taste, and very apt to cause diarrhœa to those unaccustomed to it, but this passes off

with use. A very good bread is made from a mixture of rye flour and wheat flour in the proportion of 1 : 2.

Of all the cereals rye is most subject to attacks of the fungus called Ergot, a fungus which causes the grain to swell up and assume a dark-purple colour. The ergotized grains are easily sifted from the rest on account of their greater size, but when taken in large quantity they cause vomiting, convulsions, and gangrene. Ergot of rye is an invaluable drug in midwifery.

Maize, or Indian Corn, used to be reckoned the richest of the cereals in fat; but this position has now been given to oats. Maize fat has a yellowish colour, and tends to spoil on keeping; it is thus very suitable for fattening animals, but for human use it is often treated with potash to saponify its fat and at the same time remove the peculiar flavour of maize. This makes the grain more palatable but less nutritious, and forms prepared in this way go by the names of Oswego prepared corn, corn-flour, and hominy. Owing to its deficiency in gluten, hominy is used in the United States like oats for baking into "hoe-cakes" as they are called. In Italy, polenta is a kind of porridge made from maize meal and chestnuts, and in the same country there is found pellagra, a disease like scurvy, which has been traced to a maize fungus. The grain is deficient in salts as compared with other cereals.

As the analyses show, **Rice** is much less nutritious than the other cereals, being deficient in everything but starch, which, however, it contains in a very digestible form, almost unaccompanied by cellulose. On account of this poorness in proteids, fats, and salts, rice is rarely taken alone, but combined with other foods like meat or legumes, rich in proteids, or made into puddings with eggs or milk. It cannot be made into bread, but rice flour is often added to wheaten flour, especially in France, to give a white bread close in texture. Rice forms the staple food of one-third of the human race.

The whole grain is called "Paddy", and is coloured in various shades of yellow; when this coloured skin has been removed the grain is known as rice. Since rice contains such a small proportion of proteids and salts it should not be boiled, or, if boiled, the rice-water should be concentrated and used for stock. The best way of cooking rice is by steaming until the starch grains burst. Rice-water flavoured with sugar and lemon is a favourite cooling drink in India. According to Parkes, the larger American grains have often much less flavour than the smaller and less attractive Indian varieties.

Millet, *Sorghum*, *Darra*, &c., are names given to various grasses of the millet order, and they get the reputation of being the earliest grain used in bread-making. It is richer than rice, and is extensively used in West Africa, Algiers, and the south of Europe, while in some parts of India and China it displaces every other grain. Millet has the further advantage of keeping well.

Buckwheat, in spite of its name, is not a cereal at all, but belongs to the Polygonaceæ, the order which includes the dock, sorrel, and knot-grass. Like rice it is poor in proteid and fat, but it contains much indigestible cellulose. In this country it is generally used for feeding pheasants, but in France, especially Brittany, under the name of "blé noir", it makes a fairly nutritious and palatable bread, and in the United States and Holland it is baked into cakes.

SUMMARY.

1. Oats rank with wheat in abundance of proteids, and are the richest of the cereals in fats and salts.
2. In the form of oatmeal jelly they are the most readily assimilable of vegetable foods.
3. Barley is the grain chiefly used for malting. It is nearly as nutritious as wheat, especially in the form of pot-barley.
4. Rice is the poorest of all the cereals, containing little else than starch.

Lesson 32.—LEGUMES.

Legumes or pod-bearing plants head the vegetable kingdom in respect of richness in nitrogenous substances, the chief proximate principle in them being Legumin, or vegetable casein. They also contain a good deal of starch, and are richer in salts than the cereals, especially in potash and lime, though poorer than these in magnesia and phosphates. Combined with the legumin there is a good deal of sulphur and phosphorus, especially in beans and peas, and the former forms within the body sulphuretted hydrogen and similar compounds, so that a leguminous diet tends to cause flatulence. In point of actual nutriment, however, lentils contain twice as much as the same weight of wheat. They are deficient in fats, a

defect recognized in the popular combinations of beans and bacon, green peas and ham, boiled pork and pease-pudding, and the leguminous purées made up with butter or lard, as in the Erbswurst or pea-sausage of the German army. They are rather indigestible, containing as much as 6½ per cent of insoluble matters, and hence are unsuitable for persons of sedentary occupations, except now and then to remedy constipation. For active open-air workers legumes will be found equal to meat in nutritive powers. On account of the absence of gluten they cannot be baked into bread, and their peculiar taste sometimes renders them objectionable. They dry very hard, and need to be thoroughly soaked, for twelve to twenty-four hours before cooking, in the softest water obtainable, after which they must be boiled gently in soft water, since the lime and magnesia found in hard waters form insoluble compounds with legumin. A comparative analysis of the leading leguminous plants is thus given by Bauer:—

	Water.	Proteids.	Fat.	Starch, &c.	Cellulose.	Ash.
Peas, ...	14·31	22·63	1·72	53·24	5·45	2·65
Beans, ...	13·60	23·12	2·28	53·63	3·84	3·53
Lentils, ...	12·51	24·81	1·85	54·78	3·58	2·47
Wheat, ...	13·56	12·42	1·70	67·89	2·66	1·79

Of all the Leguminosæ the most important is the **Pea**, of which there are two kinds, the field pea and the garden pea. The former is used in the pods for feeding cattle, while for human food they are shelled, split, and sold as split peas, or ground into pea-flour or pease-meal. The garden pea is eaten unripe, and in a still more immature state it is served up, pods and all, as *haricots verts.* The fresh ripe pea is sweetish, and should be cooked by simple boiling in water with a little salt; but when old they lose much water, becoming very hard and dry, lose their colour, and get much shrivelled, so that they must be steeped a long time in water in order to soften them; or, since boiling rather hardens them if very old, the French fashion may be adopted of stewing them gently in a little water with butter, a little salt, and flavourings to taste. In order to preserve the colour, which pales on keeping, copper is often added to green peas to the extent of 2 grs. per pound tin. Whether such an addition is harmful is an open question,

but there is good reason to believe that copper will for this purpose be displaced by chlorophyll, the natural green colouring matter of plants.

Peas are not so nutritious as beans, since not only do they contain more indigestible matter, but are poorer in fat and proteids; pea-albumen differs from ordinary albumen both in composition and behaviour. Pea-flour does not keep very well, and putrefying peas form a poison of the ptomaine class. When hot water is added to bean or pea flour it gives off the peculiar bean odour.

The following analyses will give some idea of the composition of peas:—

	Peas.	Pease-meal.
Water, ...	11·01 to 22·12; average, 14·31	Water, 14·1
Proteids, ...	18·56 „ 27·14 „ 22·63	Legumin, 23·4
Fat, ...	0·64 „ 3·30 „ 1·72	Starch, 37·0
Nitrogenous extractives,	41·90 „ 59·38 „ 53·24	Sugar, ... 2·0
Cellulose, ...	2·22 „ 10·00 „ 5·45	Gum, ... 9·0
Ash, ...	1·76 „ 3·49 „ 2·65	Fat, ... 2·0
		Cellulose, 10·0
		Ash, ... 2·5

A condensed form of pea-soup is prepared in Germany for military purposes, and the following analyses by König will at once convey an idea of its nutritive value:—

	No. 1.	No. 2.
Water, ...	7·58	8·08
Proteids, ...	16·93	15·81
Fat, ...	8·98	24·41
Carbohydrates, ...	53·44	36·78
Cellulose, ...	1·34	1·69
Ash, ...	11·73	13·23

The Erbswurst or pea-sausage, supplied to the German troops in the winter of 1870–71, consisted of dried and powdered meat thoroughly mixed with pease-meal under pressure.

In China and Japan another variety of pea is used in the form of cheese. It is very poor as a food-stuff, having fully 90 per cent of water, and containing only $2\frac{1}{3}$ per cent of fatty matters and less than 1 per cent of proteids.

The **Beans** used for food in this country are chiefly the broad or Windsor bean, and the kidney or haricot bean, an

entirely different plant, along with the scarlet runner, used in London district. The common field or horse bean is chiefly used for cattle; it contains less nutriment and more indigestible matters than the Windsor bean. The latter should be young, as when old the skins become leathery and indigestible; they should burst on boiling. The following table gives a comparative analysis of the common and haricot bean:—

	Broad Beans.	Haricots.
Water,	14·34	13·60
Proteids,	23·66	23·12
Fat,	1·63	2·28
Carbohydrates,	49·25	53·63
Cellulose,	7·47	3·84
Ash,	3·15	3·53

The **Haricot** or French bean, and the scarlet runner, belong to the same family. The latter is chiefly used as a green vegetable, being served up in the pods under the name of *haricots verts.* The *haricots blancs,* or simply "blancs", are served in France in a variety of ways, boiled in water and served with butter, salt, and pepper like peas, or mixed with *flageolets, i.e.* preserved green haricots, and similarly treated, forming "haricots panachés", or boiled in gravy and dished with mutton. They can be mashed into purée, or used to thicken soup, or used as a salad flavoured by adding tomato or similar vegetables. Sir Henry Thompson is loud in praise of haricots. "There is no product of the vegetable kingdom so nutritious, holding its own in this respect, as it well can, even against the beef and mutton of the animal kingdom. The haricot ranks just above lentils, which have been so much praised of late, and rightly, the haricot being also to most palates more agreeable. By most stomachs, too, haricots are more easily digested than meat is; and, consuming weight for weight, the eater feels lighter and less oppressed, as a rule, after the leguminous diet; while the comparative cost is very greatly in favour of the latter. I do not, of course, overlook in the dish of simple haricots the absence of savoury odours proper to well-cooked meat; but nothing is easier than to combine one part of meat with two parts of haricots, adding vegetables and garden herbs, so as to produce a stew which shall be more nutritious, wholesome, and palatable than a stew of all meat and no haricots. Moreover, the cost of the latter will be more than double that of the former" (*Food and Feeding,* p. 40).

Lentils rank with haricot beans as the most nutritious of the Leguminosæ. Their general composition is as under:—

Water, ...	12·51
Proteids, ...	24·81
Fat, ...	1·85
Carbohydrates, ...	54·78
Cellulose, ...	3·58
Ash, ...	2·47

They are thus richer than peas or beans in nitrogenous substances; their ash is richer in phosphates, potash, soda, and lime, and contains 2 per cent of iron oxide. They contain no sulphur, and are therefore not open to the objection of causing flatulence; indeed, lentils mixed with peas in making pea-soup greatly diminish that tendency. Lentils themselves make excellent soup, but like all legumes they need to be steeped in water twelve hours or so before boiling. They are sold as split lentils, and also as lentil flour.

There is a preparation greatly advertised as food for dyspeptic patients, Revalenta Arabica, consisting of lentil flour, with either pea, bean, or maize meal, and a little oat or barley-meal, heated together in an oven. Beneke's flour for cancer cases consists of lentil flour, with rye flour added to increase the amount of starch.

SUMMARY.

1. Legumes are quite equal to meat in respect of proteids, but contain much indigestible matter, and their proteid, legumin, is not so assimilable as albumen.
2. Haricot beans are the most nutritious and palatable form of legumes.
3. Lentils are distinguished from peas and beans by absence of sulphur.

Lesson 33.—ROOTS AND TUBERS.

The roots and tubers used for food comprise the various kinds of potato, yam, Jerusalem artichoke, with the different plants yielding arrowroot and tapioca, among which may be reckoned sago.

The type of all these is the **Potato**, which, as will be seen from the appended analysis, consists to the extent of 95 per cent of water and starch. Their proteid matter is exceedingly

small, and the rest of the solids is made up of sugar, pectin or vegetable jelly, and the vegetable acids. The composition of the potato is given in the following analyses:—

No. 1.		No. 2.	
Water, ...	71—80	Water, ...	75·77
Starch, ...	15—20	Starch, ...	20·56
Fibre, ...	3—7	Fat, ...	0·16
Gum, dextrin, sugar, &c., ...	3—4	Cellulose, ...	0·75
		Proteids, ...	1·79
Proteids, ...	2	Ash, ...	0·97

As these show, 95 per cent of the potato consists of water and starch. The nitrogenous matter is very slight, and even of that fully the half consists of asparagin and amido-acids of no nutritive value. The Irishman who attempts to nourish himself upon potatoes has to assimilate 10 or 11 lbs. daily, while with a mixed diet of flesh, eggs, and bread, from 2 to 3 lbs. suffice; and 100 parts of wheaten flour or 107 of wheat itself are equivalent to 613 of potatoes. Since the potato is so poor in nitrogenous materials, it cannot be used alone to support life, and its deficiencies in this respect are supplied by substances rich in proteids and fat. Thus it is mashed with butter and served with milk, taken with meat, bacon, and fish, especially oily fish, cooked with butter in various ways, the pommes frites and pommes sautées of the French, or it is taken with butter-milk.

Potato juice is acid, containing citric acid combined with potash, soda, and lime, and it has thus a high value as an antiscorbutic, this quality being due not so much to the potash, as to the citric and succinic acids present in small quantities along with oxalic acid. The water in which potatoes have been boiled is not wholesome, and cannot be used for stock; young potatoes especially are great offenders in this respect, and it is necessary to steep them in water first to remove as much as possible of the acrid "green" juice before boiling. Severe diarrhœa has been caused by indiscriminately eating new potatoes containing unformed starch and immature cell-tissue.

The value of the potato as a food-stuff lies in its starch, and it is from potatoes that starch is generally obtained by maceration with water. It is calculated that in this respect more food can be got per acre from potatoes than from any other British food-plant. Potatoes are never eaten raw, but roasted or boiled; the latter process removes the narcotico-irritant poison sometimes present. On boiling, the small quantity of albumen

present is coagulated, and the starch cells burst, liberating the starch, some of which may be turned into dextrin, which is soluble, and gives the potato a watery consistence. The object aimed at is the production of a "mealy" consistence, in which state the starch is very easily digested. To avoid loss of salts potatoes should be cooked "in their jackets", since the small amount of albumen is not sufficient to form a protective skin as in meat; or, still better, they should be steamed. Cold boiled potatoes are often sliced and served in salads.

Potatoes may be stored in pits or by keeping in a cool, *dark*, well-ventilated cellar, so as to keep out light and frost. The addition of a pound of lime to each barrel absorbs the unpleasant earthy odour. Exposure to light makes potatoes green, bitter, and unwholesome, as is sometimes seen when a surface potato has been exposed by rain. Potatoes taken too early from the ground are apt to heat and sprout when stored. The potato disease is caused by a fungus which spreads its thread-like stems among the tissue. Diseased potatoes are indigestible in the highest degree, and should not be eaten at all.

The **Sweet-potato** or Batatas is an entirely different plant, and next to maize forms the food of the poorer classes in the United States; it is also used in France and Spain. It contains 16 per cent of starch and 10 per cent of sugar, whence its name. Like the potato, it becomes mealy when boiled, and it furnishes a sweet, wholesome, somewhat laxative diet.

Yams are the tropical substitute for potatoes. Like them they contain an acrid substance, dissipated on boiling, though several species are very nauseous after boiling, and some even poisonous. The yam contains a large amount of starch and cooks mealy, without the sweetness of the sweet-potato.

The **Jerusalem Artichoke** is the tuber of a species of sunflower, Jerusalem being a corruption of the Italian girasole, a sunflower, while the other part of the name is due to the supposed flavour of the tuber. It contains only 2 per cent of starch in the form of *inulin*, and therefore never cooks mealy like potatoes. On the other hand, there is present 14 per cent of sugar and 3 per cent of nitrogenous substances, so that it is sweet, very watery, and mucilaginous when boiled, making good soups and sauces.

Arrowroot is now a generic term given to the starches obtained from the roots of several plants such as Maranta, Curcuma, Canna, Tacca, and Cassava. The Maranta root, or rather rhizome, contains 26 per cent of starch and about 2½ per cent

of albumen, gum, and salts, but in the process of preparation nothing is left but pure starch. The roots are dug up when a year old, washed and made into pulp, then macerated with water through sieves which separate all the cellulose. The final product is a fine white starch crackling under the fingers on pressure just as dry snow does, and having neither taste nor smell. It has no dietetic value whatever except as starch, and as Mr. Williams has pointed out, the dietetic difference between ordinary commercial starch and the finest and most expensive arrowroot is almost nil. Being a very pure starch, on adding boiling water it dissolves completely, evolving a peculiar odour, and sets to a jelly on cooling. It is made with milk into puddings or dissolved in excess of boiling water, flavoured with sugar, lemon-juice, &c., and used as a beverage. The arrowroot most highly valued is West Indian or Bermudas arrowroot, derived as above from the Maranta; the next in value is from Jamaica. East Indian arrowroot is highly esteemed; it contains the starch of Curcuma, a species of turmeric. West Indian arrowroot is also prepared from Canna or Tous-les-mois; Tahiti arrowroot from the Tacca plant. This last, like the potato, is acrid, and requires maceration in water. It is generally eaten with vinegar or other acids, and is said to be an effectual cure for dysentery, which other arrowroot is not. Portland arrowroot is the starch obtained from the roots of the common arum, while English arrowroot is simply potato starch. All the varieties are adulterated with sago, tapioca, and potato starch.

Another starch-yielding tuber is that of the Manihot, manioc, mandioc, or cassava plant. The roots have an acrid milky juice, speedily fatal owing to the presence of prussic acid. This is dissipated by heat, then the roots are grated, dried on hot metal plates and powdered. The starch thus obtained, sometimes called Brazilian arrowroot, is made like oatmeal into cakes known as cassava bread. From it **Tapioca** is made by heating it on a hot plate with constant stirring. The starch grains burst, some of the starch becomes dextrinized, and the whole gathers into small irregular masses known as Tapioca. It is agreeable, easily digested, and used like the other arrowroots for milk-puddings and soups.

Salep was formerly much more used in England than now. It is an orchidaceous plant, and of the two tubers which it bears the younger and more solid is taken, in size varying from a cherry-stone to an olive. The tubers are cleaned, dipped

for a few minutes in boiling water, then dried as quickly as possible. This makes them hard and horny, and they are ground into powder; boiling water is added with sugar and milk according to taste. It is a diet drink, and before the introduction of coffee was a favourite early morning drink with the British workman, and it is still so used in France. It is nutritious and soothing, and besides starch contains phosphate of lime and mucilaginous matters.

Although not a tuber, **Sago** may be classed with the above substances. It is the pith of a palm cultivated in Sumatra and the East Indies generally. After the tree has flowered the leaves begin to exude a floury substance, a sign that the tree is ripe. It is cut down within the year, cut into lengths, split open, and the pith extracted. The cellulose is separated as in arrowroot, by maceration through sieves, and the starch which settles at the bottom of the washings is dried in the usual way. It is not quite soluble in water as ordinary starch is, and is therefore suited for puddings, &c. Sago is light, cheap, nutritious, and easily digested.

Vegetable Roots.—The next class of vegetables are valued as esculents rather than as food-stuffs. They contain a large amount of water, 90 per cent, about 2 per cent of proteid matter, and 7 per cent of starch, but they are chiefly useful as antiscorbutics on account of the salts they contain.

Carrots when young are useful and wholesome. They contain from 85 to 88 per cent of water, 8 of carbohydrates, 1 of salts, and fully 1 of proteid substances. The pale central portion consists almost entirely of woody fibre, and cultivation aims at increasing the outer red fleshy portion. The carbohydrates are mostly sugar and pectose, but the carrot cannot be said to be very digestible.

Parsnips contain as much as 16 per cent of food-stuffs, mostly sugar. Though their flavour is disliked by some, they are more nutritious than carrots, and their sweetness renders them a favourite with children. When left too long in the ground they get "rusty", and after beginning to sprout in spring they become acrid. They are best after a touch of frost, and are all the more acceptable, as then the potatoes are getting bad. They form good winter feeding, and cows fed upon parsnips not only show an excellent quality of flesh but produce butter superior to that obtained from any other kind of winter feeding.

From their large quantities of sugar, parsnips are often

made in England and Ireland into a wine not unlike Malmsey; in the north of Ireland the root is also fermented into a kind of beer with yeast and hops.

Turnips are decidedly inferior to carrots in nutritive power, containing, as it does, from 90 to 96 per cent of water, and yet it is largely used for cattle-feeding. It contains only 1 per cent of nitrogenous matter, and may have as much as 6 per cent of carbohydrates, though the most of this is cellulose, especially in old plants. The young leaves of the turnip, turnip-tops, are used as greens; the best for this purpose being those of young Swedes.

Turnips used for feeding cows communicate their taste to the milk. To remove this all that is necessary is to stand the milk before a fire till the temperature rises to 65° F. before churning.

Kohl Rabi, properly Kohl-Rübe, Kale-turnip, is used like turnips rather than like cabbage, although the stalks also are eaten. It is solid, and more nutritious than any turnip of the same size.

Beet-root contains 87 per cent of water; 9 of carbohydrates, chiefly sugar; 1½ of proteids; and 1 of salts. It is grown for the sake of its sugar, though the root itself is sliced and pickled or used in salads. In lifting and cleaning the root care must be taken not to break the surface, otherwise it "bleeds". White beet is grown for the sake of its leaves, which are used like spinach, and as a substitute for the latter at the beginning of spring. Mangold-wurzel, so much used for feeding cattle, is a coarse beet-root.

Radishes, when young, are used in salads for the sake of their pungent and antiscorbutic properties. They have a stimulating effect upon the urinary organs, and act as demulcents, being often given to remove excess of mucus from the stomach and bladder.

Salsafy or *Salsify* is one of the Goat's-beard family, and is like the parsnip in composition. It is used like carrots, and has an asparagus flavour. The roots of the purple goat's-beard are also used in the same way.

SUMMARY.

1. Vegetable roots are used either for their antiscorbutic properties or for the starch obtained from them.

2. They are all exceedingly poor in nitrogenous and fatty sub-

stances, consisting almost entirely of water, starchy matters, and salts.

3. The different forms of arrowroot are starch pure and simple, and have no more dietetic value than common potato starch.

4. Roots used entire, such as radishes, carrots, parsnips, &c., are valued for their salts rather than for any nutriment in them.

Lesson 34.—GREEN VEGETABLES.

Green vegetables are even less nutritious than roots, and are valued mainly for their antiscorbutic salts and flavour, the latter due to various essential oils. The large proportion of cellulose among the solids makes them indigestible, but also useful as laxatives to a certain extent. They contain 90 per cent of water, and only from $1\frac{1}{2}$ to 4 per cent of proteids. Before use they should be carefully cleaned, not only by removal of dead and decaying parts, but by careful washing, and a preliminary soaking in salt is advisable to kill embryos of tape-worms and other entozoa, which generally enter the body in this way.

Of all green vegetables the **Cabbage** tribe of the Cruciferæ bulk most largely. This natural order, easily recognized by the shape of the flower, furnishes several important food accessories, and does not contain a single poisonous plant—a fact of some importance to explorers. Cabbages all contain sulphur, and are therefore flatulent in effects; boiling dissipates a good deal of the sulphur compounds, besides softening the cellulose, but cabbages are never so digestible as when young, and eaten raw with vinegar. They are used in broth, as salads, or mashed.

Cauliflower is the inflorescence of a species of cabbage. It is the most delicate and digestible of all the cabbage products. *Broccoli* is a variety of cauliflower, inferior in flavour.

Kale or Greens have open heads of leaves, and the more the leaves are curled the more highly are they esteemed. German greens are the most delicate.

Sea-kale consists of the young sprouts of the sea-cabbage excluded from light, as, if exposed to light, they are neither tender nor pleasant, but develop an acrid taste. They are delicate in flavour, nutritive, and easy of digestion.

Brussels Sprouts are little clusters of leaves resembling cabbages, formed in the axils of the main leaves. The *Savoy* is another well-known variety of cabbage.

Sauer-kraut is a German preparation of white cabbage leaves. When the hearts are firm and white the leaves are taken out, laid in layers with salt between, pressed under a board, and set aside till fermentation commences. When a sour smell arises from the cask the sauer-kraut is removed into a cool place and kept for use. It is generally eaten boiled like fresh cabbage.

Spinach or *Spinage* is a favourite vegetable, and is used in this country much as the sorrel is in France, for clearing the complexion. Burney Yeo quotes the proverb,

> "Par l'epinard et le poirreau,
> Fleurit le lys clair et le peau",

which may be freely rendered, "Spinage and leek, keep the skin sleek". The young leaves and even the stems are used, either boiled or fried with butter, but they are best cooked in a purée. After the stem gets mature the leaves become bitter, and are then unfit for use. Its aperient qualities are due to the fact that it consists almost entirely of cellulose, and therefore proves beneficial in habitual constipation.

Celery is cultivated either for its roots or for the blanched leaf-stalks. It is eaten raw, alone or in salad, and is used to flavour soups. The stalks contain an aromatic oil, sugar, mucilage, starch, and manna-sugar, and the last acts as a stimulant of the uro-genital organs. The daily moderate use of celery as salad is said to remove nervousness, and even palpitation of the heart; for this purpose celery may be used when in season, and onions when out. A recipe for its use in rheumatism is thus given in the *Garden Advertiser*:—The celery should be cut into bits and boiled in water until soft, and the water should be drunk by the patient. Put new milk with a little flour and nutmeg into a sauce-pan with the boiled celery, serve it warm with pieces of toast, eat it with potatoes, and the painful ailment will yield. The proper way to eat celery is to have it cooked as a vegetable after the manner above described.

Green Artichoke is a species of cultivated thistle, and the part used is the receptacle, called by children "cheese" in the ordinary thistle. The heads are cut before they expand, and are either boiled or eaten raw with salt and pepper. The

central leaf-stalks are also eaten in the same way. It contains tannin as well as mucilage, and is easily digested.

Asparagus is a vegetable of long standing as a delicacy, being mentioned as early as 425 B.C., and held in high esteem by the Romans. The green asparagus is the best variety, and it grows to perfection among the vines in Germany and France. The seeds are sometimes used on the Continent instead of coffee. It is only slightly nutritive, but it contains a crystalline nitrogenous substance called Asparagin, which produces marked physiological effects. It is used as a cardiac sedative in palpitation, but is best known as a diuretic, communicating a disagreeable smell to the urine and largely increasing its flow; long-continued action even produces bloody urine. Asparagus is on this account often used as a solvent for urinary calculi, an infusion of the root being used for this purpose. Like celery, it has an aphrodisiac action.

Nettles are often used in broth for clearing the complexion. The tops are cut when young, minced fine, and scalded with boiling water, which destroys the stinging juice, then added to ordinary broth.

Lettuces are cooling, easy of digestion, antiscorbutic and moderately nutritious, and gently laxative in their action. They are rarely boiled, but generally eaten raw, with vinegar and oil. The milky juice of the lettuce is somewhat narcotic, and is used as a sedative.

On the general subject of **Salads** one cannot do better than quote in full the directions of Sir Henry Thompson (*Food and Feeding*, p. 116):—The materials must be secured fresh, and are not to be too numerous and diverse, must be well cleaned and washed without handling, and all water removed as far as possible. It should be made immediately before the meal, and kept cool until wanted. Not many servants can be trusted to execute the simple details involved in cross-cutting the lettuce, endive, or what not but two or three times in a roomy salad-bowl, placing one salt-spoonful of salt or half that quantity of pepper in a table-spoon, which is to be filled three times consecutively with the best fresh olive-oil, stirring each briskly until the condiments have been thoroughly mixed and at the same time distributed over the salad. This is next to be tossed thoroughly but lightly, until every portion glistens, scattering meanwhile a little finely-chopped fresh tarragon and chervil, with a few atoms of chives, over the whole, so that sparkling green particles spot as with a pattern every

portion of the leafy surface. Lastly, but only immediately before using, one small table-spoonful of mild French, or, better still, of Italian red-wine vinegar is to be sprinkled over all, followed by another tossing of the salad.

The **Onion** is used as a vegetable and condiment, the parts used being chiefly the bulb, and also the young leaves and the seedlings, known in Scotland as *Syboes*. The onions produced in warm countries are larger in size but milder in taste, and slightly laxative; a Spanish onion, raw and eaten like an apple, forms with a bit of bread a working-man's lunch. The *Shallot* or Eschalot is a delicate onion with a stronger taste, but without the pungent smell of the onion. *Chives* is a British variety, of which the young leaves as well as the bulb are used in salads and for soups. The Welsh onion or *Cibol* is much larger than the chive, and is also valued for its tender leaves. The *Leek* belongs to the same class.

The Onion family are very nutritious, containing a large quantity of nitrogenous materials and sugar in the colloid form, as well as a pungent oil rich in sulphur, to which they owe their pungency and smell. This oil is dissipated by boiling, so that boiled onions are much milder than the raw vegetable. The onion is valuable as a blood purifier; it stimulates the secretions, and, like celery, it is said to be useful for nervousness. The "personal equation" figures largely in the use of onions, as some persons cannot tolerate them at all, while others eat them raw with apparent relish. Roasted and oiled they form a useful poultice for suppurations.

Garlic belongs to the onion family of plants, but differs from onions in having a bulb composed of bulblets or "cloves", whereas the onion bulb is simple. In Spain it forms part of almost every dish, ranking thus along with pulse and grain as a sustainer of strength, owing to its richness in nitrogenous and carbonaceous substances. Used as a condiment it is a stimulant and tonic, and therefore promotes digestion; it also acts on the kidneys and skin, increasing their excretion of water, and indeed the excretions generally. Like onions it is used externally for poulticing, and acts as a rubefacient. It is also used for intestinal worms, and a clove of garlic or a few drops of garlic juice put into the ear relieves some cases of deafness.

The peculiar properties of garlic are due to oil of garlic, which consists chiefly of sulphide of allyl, a substance found also in all the onion family, as well as in water-cresses,

radishes, asafœtida, and scurvy-grass, all of which owe their pungency to this oil. Oil of mustard is allyl sulphocyanide, and can now be prepared from oil of garlic, or *vice versa.*

Gourds form a large class of plants closely allied botanically to the cucumber, and they are grown in all warm climates. The common gourd or *Pumpkin* is much grown in the United States, where it may attain a weight of 70 lbs. Not only is it used for feeding cattle, but also as food by the poorer classes. It is never eaten raw, but made into soups or sliced and fried in oil, or made into pies with apples, &c. A hardy variety of pumpkin is the *Vegetable Marrow,* of all the gourds the one most cultivated in Britain. It is pleasant and digestible, but is more of a drink than a food, its proportion of water being so high. The form most suited for food is the Great gourd, either in the green Spanish form or the great yellow gourd, which sometimes attains a weight of 200 lbs. The *Squash* is another form of gourd. The Orange gourd is sometimes unfit for use, since it contains a quantity of colocynth, which gives it a bitter taste.

Cucumbers are generally used in salad or pickled in the young state, when they are known as *Gherkins.* Some species are used in soups, while from others the drug Colocynth is obtained. Raw cucumbers are very apt to prove irritants in persons of weak digestion.

Belonging to the cucumber family is the **Melon,** of which there are several varieties, differing in the colour of the flesh —yellow, green, or red as in the "blood" melon—and also in the appearance of the rind. It is more a drink than a food, since the solids in it amount to only 5 per cent, and this is especially the case with the *Water Melon,* the juice of which is an agreeable and cooling drink, allaying fever as well as quenching thirst. Melons are eaten raw or with sugar, but sometimes with spices, such as ginger or pepper. The seeds of the *Kaukoor,* an Indian melon, contain a good deal of starch and vegetable fat; they are ground into meal, while the oil is used for lighting. The plant itself appears in pickles, and enters into various Indian dishes. Although so watery it is very indigestible.

The **Tomato** or Love-Apple, although a fruit, is generally used as a vegetable, and may be treated here. It comes originally from the tropical part of America, but is extensively grown in the United States and the south of Europe, and its use in Britain is yearly increasing. In Italy, indeed,

it appears in almost every dish, and there is no other fruit capable of being served in so many different ways. It may be boiled, fried, baked, roasted, stewed, pickled, preserved in various ways; and may enter into sauces, soups, ketchups, salads, &c. The unripe fruit makes one of the best of pickles. Itself the "prince of salads", the tomato is never better than when eaten fresh and raw. If cooked at all it should be in a plain manner, so as not to destroy its natural flavour, and it may be served hot, or eaten cold with salt and pepper, or sugar. Raw tomatoes should not be sliced for salad or such purposes until the last moment, since the juice speedily drains off, leaving simply a cellulose framework. "To serve a hot tomato by stuffing it with onion, parsley, and shallot, is mischievous meddling carried to its highest pitch."

The tomato owes its pleasant sour taste to oxalic acid, and on that account, like rhubarb stalks, it is generally forbidden to those of gouty tendency, since oxalic acid forms insoluble salts with lime and magnesia. There was an opinion current that tomatoes encouraged cancer, and somehow a report spread that patients at the London Cancer Hospital had been forbidden to use tomatoes. This report was promptly contradicted by the superintendent, who, so far from condemning the tomato, extolled it as "a wholesome article of food, particularly so if cooked".

The common **Sorrel**, Scotch sourock, the little sour plant, is also rich in oxalic acid, like the *Oxalis* or wood-sorrel, and it is on that account used in salads and sauces, and on the Continent in soups, to which it gives a tart flavour resembling tomato soup.

The leaf-stalks of **Rhubarb** also contain oxalic acid, along with citric and malic acids. They are largely used for tarts and pies, and also when young for preserving in syrup like ginger. Excessive use of rhubarb tends to thin the blood and produce outstrikes on the skin.

SUMMARY.

1. Green vegetables contain little nutriment, but are valued for their essential oils and antiscorbutic salts, as well as for their laxative effects due to cellulose.

2. The cabbage tribe all contain sulphur, and therefore tend to flatulence.

3. The onion tribe are nutritious, and contain oil of onions.

4. Gourds and melons contain little else than water, and are rather useful as cooling drinks than as foods.
5. Tomatoes, sorrels, and rhubarb contain oxalic and other acids.
6. Asparagus and celery have distinct medicinal effects.

Lesson 35.—FUNGI.

Fungi bulk very largely among the food-stuffs of southern Europe, especially among the poor in France, Germany, and Italy; in the Roman market alone the yearly turnover of fungi amounts to £4000. They are eaten raw, and since they all decompose easily they cannot be eaten too fresh; but they are also used dried, or preserved by cooking in brine, olive-oil, or vinegar, which takes away the acrid qualities of some of the more suspicious varieties. Fungi are fairly rich in nitrogenous substances, though it is doubtful if these are assimilated; they all contain fatty matters, fungic acid, and sugar as mannite and dextrose, while some contain an acrid substance which is destroyed as above, and also dissipated on boiling. They are used in this country chiefly for their flavour, and also for pickling and making ketchup. The personal equation bulks largely in the use of fungi; common mushrooms even prove irritating in the highest degree to some people.

Poisonous fungi are comparatively few, but as they closely resemble the edible forms, some distinctions must be observed. The common notion that poisonous fungi might be detected by discolouring a silver spoon owing to the presence in them of sulphur compounds is unreliable. The poisonous varieties are recognized generally by their high colour, scaly or spotted surface, and flesh either tough or watery. They usually grow in clusters upon wet or shady ground. On bruising they show a play of colours and yield a pungent milk, while their taste is bitter or burning the throat; on drying they become bluish. The poisonous matters in these belong to the class of narcotico-irritants, and cases of poisoning are best treated by the free use of emetics and castor-oil. Edible fungi, on the other hand, are seldom high-coloured, scaly, or spotted, but are generally red or brownish. They break with a brittle fracture, retain their colour on drying, and grow best upon open, dry pastures. They have an agreeable smell and taste, but in some species any acrid taste may be dissipated by heat.

The chief edible fungi are the common *Mushroom*, generally used for making ketchup; the St. George's Agaric or White-cap, similar but much inferior; the Fairy-ring mushroom, Scotch bonnets or Champignon, a smaller plant, with a strong agreeable odour, and much used in ketchup and sauces; and several other species of mushroom. The common *Morel* is rare in Britain, though much used in Germany, and makes excellent ketchup. *Truffle* is a subterranean fungus grown in the south of Europe, chiefly in the chestnut forests of France and Italy, where it is rooted out by dogs trained for the purpose. The black truffle is the most highly valued for flavour and smell, and it enters into many dishes. The white truffle is less aromatic, but is used in the same way. Both forms are highly indigestible.

Iceland-moss is a lichen found in arctic and subarctic districts, and is valued both as a food and a medicine. In Iceland and Norway it is gathered during the summer months for food, and is even exported. It contains a bitter acid, cetraric acid, which is removed by steeping in water, then the moss is pounded and made into bread, or else boiled with milk like a farinaceous food. Iceland-moss possesses 80 per cent of starch of the kind called Lichenin or lichen starch, and it has been recommended to diabetic patients as a substitute for ordinary bread; *inulin* biscuits have been suggested for the same purpose.

Irish or Carrageen Moss is not a moss at all, but a sea-weed, *Chondrus crispus*, which is found along our own shores. After being gathered it is dried for export, and thus prepared has the following composition:—

Vegetable jelly	79·1	per cent.
Mucin, ...	9·5	„
Resins, ...	0·7	„
Ash, ...	2·0	„
Fibre and water, ...	8·7	„

A very pleasant drink is obtained by adding cold water in the proportion of half an ounce of carrageen to three pints of water, then boiling and straining. It may be flavoured by spices if desired. When more carrageen is used the result is a mucilage, yielding a jelly on boiling, and this mucilage may be added to milk for infants just like barley-water, or it may be boiled with milk so as to form a "shape" on cooling, like blanc-mange. It is nutritious, easy of digestion, and a plea-

sant article of food, and has been much praised in cases of pulmonary consumption.

Mushroom Ketchup is made from the common mushroom by breaking it into small pieces and mixing with salt, which acts upon it so as to reduce the whole mass to an almost liquid state, then straining and boiling down to about half the bulk. Spices of different kinds are added, and sometimes wine. Mushroom ketchup must be kept in corked bottles.

Walnut ketchup is made from unripe walnuts before the shell has hardened. They are beaten to a pulp, and the juice separated by straining; salt and vinegar are added, also spices, and after considerable boiling down the ketchup is bottled, and may be kept for years.

Tomato ketchup is made in a similar manner from tomatoes, but without being strained.

SUMMARY.

1. Fungi are nitrogenous in composition, but contain much water, and are scarcely assimilated.
2. Iceland-moss is a valuable farinaceous food, containing 80 per cent of starch.
3. Carrageen moss contains 80 per cent of vegetable jelly, and is used in infant feeding.

Lesson 36.—FRUITS.

Man has been asserted to be naturally a frugivorous animal who by habit has become omnivorous, and it is certain that, taking the word in its botanical sense, fruits exceed in human value all the other parts of plants. In cereals they are valued for their farinaceous matters, starch, fat, and gluten; in succulent fruits for their water, sugar, free acid, and salts; in the banana, plantain, and bread-fruit for their starchy pulp; in nuts for their oils; while a great many of them, as pepper, cloves, vanilla, are used as condiments.

Using the term in its restricted and popular sense, it will be seen from the above table that all fruits contain nitrogenous substances, and are so far tissue-forming, but this is so very small in amount that to sustain the body on fruits alone would demand enormous quantities of fruits; thus to replace one egg in food-value there would be needed more than 1 lb. of cherries,

COMPARATIVE ANALYSIS OF FRUITS. (BAUER.)

	Fresh Fruits.							Dried.			
	Apple.	Pear.	Peach.	Grape.	Straw-berry.	Currant.	Orange (pulp only).	Apple.	Cherry.	Raisin.	Fig.
Water, ...	83·58	83·03	80·03	78·18	87·66	84·77	89·01	27·95	49·88	32·02	31·20
Proteids, ...	·39	·36	·65	·59	1·07	·51	·73	1·28	2·07	2·42	4·01
Free acids, ...	·84	·20	·92	·79	·93	2·15	2·44	3·60	...	...	1·21
Sugar, ...	7·73	8·26	4·48	24·36	6·28	6·38	4·59	42·83	31·22	54·26	49·79
Other non-nitrogenous substances, ...	5·17	3·54	7·17	1·96	·48	·90	·95	17·0	14·29	7·48	4·51
Cellulose, kernel, seeds, &c.	1·98	4·30	6·06	3·60	2·32	4·57	1·79	4·95	·61	1·72	4·98
Ash, ...	·31	·31	·69	·53	·81	·72	·49	1·57	1·63	1·21	2·86
Fat, ...	...	...	Not estimated.			...	...	·82	·30	·49	1·44

nearly $1\frac{1}{2}$ lbs. grapes, 2 lbs. strawberries, fully $2\frac{1}{2}$ lbs. apples, or 4 lbs. pears. With respect to their carbohydrates fruits show more favourably, especially the grape, fig, and date, which are rich in sugar; thus 1 lb. starch = $5\frac{1}{2}$ lbs. potatoes = 5·4 grapes = 6·7 cherries or apples = 10·8 currants = 12·3 strawberries. They are, however, chiefly valued for the water in them, and the vegetable acids, free or in combination, upon which depend their valuable properties as blood-purifiers. Those acids are chiefly malic acid, characteristic of apples; tartaric, of grapes; and citric, found in lemons, oranges, and kindred fruits; and they are generally combined with potash or soda, so as to form acid salts. The ash of fruits is rich in potash salts, and contains besides those of lime, magnesia and iron; apples, and more especially strawberries, have also much soda. The agreeable aroma of the strawberry and other fruits is due to the presence in them of essential oils and ethers. They all contain *pectin* or vegetable jelly, cellulose, and the insoluble substance *pectose*, which by the action of a ferment in the plant itself is converted in the process of ripening into pectin, which thus forms the main constituent of fruit jellies. According to Fresenius, the flavour of fruits depends (1) on the ratio in which the acid stands to sugar, gum, and other carbohydrates; (2) on the presence and delicacy of the aroma, due to essential oils;. (3) on the proportion between soluble and insoluble matters and water—a peach, for example, almost melts in the mouth, whereas the bilberry is rich in insoluble materials; (4) on cultivation, which aims at increasing the proportion of sugar; (5) on favourable seasons, soil, &c. As the table shows, berries are more acid than stone fruits, and they contain relatively small quantities of gum and pectin.

Fruits are best eaten at breakfast or between meals—a good apple the first thing in the morning and the last thing at night is a standard specific for indigestion—after a heavy dinner is the worst possible time. Since the softer fruits decompose readily they should be eaten as fresh as possible. When out of season they may be taken as preserves or in the dry state, notably raisins, dates, and figs; but the expansion alike of commerce and the public taste afford now a perennial round of fruits to the consumer.

Fruits are preserved in various ways, most commonly by drying or by making them into jam just before they are fully ripe. In connection with jam- and tart-making, the remarks in a previous lesson on the inversion of sugar by vegetable acids

and by boiling, and also on the colloid condition of sugar, deserve attention. When fruits are exposed to the air, especially if the skin be broken and the surroundings are damp, or when exposed, as many of them are in transit, to considerable changes of temperature, they are exceedingly apt to decompose and suffer fermentation changes, which render them very dangerous and a fruitful source of diarrhœa. To minimize risk of damage, fruits for export are gathered while not fully ripe, in which condition there is less risk of breaking the skins, and they ripen in the shop-windows. Grapes come to this country packed in saw-dust or cork clippings to exclude air. Green gooseberries may be preserved in jars filled with sand, bran, or anything else to exclude air, then subjected to a gentle heat to expel moisture, sealed, and placed in some place, such as a cellar, where the temperature is constant. Soft fruits like pears, which go wrong very quickly, are likewise packed in saw-dust, so as to keep them from touching each other, and so to minimize infection. Of all British fruits, the apple keeps best, and some kinds of winter pears and apples can scarcely be said to have ripened till they have stood some time on the floor or in drawers, and medlars, like game, are not fit for use till they are beginning to decay.

Fruits may be classified botanically, or medicinally as laxatives, diuretics, refrigerants, &c., but it will be more convenient to adopt a more popular classification as follows:—(1) Apple, pear, quince; (2) orange, lemon, lime, shaddock; (3) stone fruits: plum, peach, apricot, cherry, olive, date; (4) acid fruits: grape, gooseberry, currant, cranberry, barberry, &c.; (5) fleshy fruits: strawberry, raspberry, blackberry, mulberry; (6) pine-apple, fig, banana; (7) nuts.

Apples are firmer than most fruits owing to the greater proportion of cellulose, and to this and to the presence of malic acid they owe their laxative properties, properties shared also by cider or apple wine. They are rich in pectin, and thus readily forms a jelly. The ratio of sugar to acid in dessert-apples varies from 12:1 up to 22:1 in the sweetest kinds; in cooking-apples it is never higher than 8 : 1.

Cider will be treated under the head of alcoholic drinks. The fermented juice of the crab-apple is known as verjuice. Biffins or beaufins are apples slowly dried in bakers' ovens, and occasionally pressed till they become soft and flat. They are prepared in great quantity in Norfolk.

Pears have less acid and cellulose than apples, and a ripe

pear should melt in the mouth like a peach. They do not keep so well as apples, and are best eaten raw; but they may be preserved in syrup, or sliced and dried in the sun or in ovens, a practice very common in France. Perry is pear-wine, prepared like cider, and similar in properties.

The **Quince** is harder than the above, and is rarely eaten raw. Stewed with sugar it may be eaten alone or used to flavour apple-pies. Quince marmalade is often made from it, and the seeds are so rich in mucilaginous substances that they convert from 40 to 50 times their own weight of water into a syrup. Like apples and pears they may be fermented.

To this class also belongs the **Medlar**, which is very hard even when ripe, and is thus "bletted", *i.e.* allowed to decay, so as to soften its tough pulp.

Oranges and all the other members of the citron family are characterized by an abundance of free citric acid, notably so in the lemon and lime. Since the proportion of water in these is high, they have little nutritive power, being chiefly used for allaying thirst, and especially useful for that purpose in febrile disorders; but their outstanding virtues are their antiscorbutic properties. There are several varieties of sweet orange, distinguished by shape, thickness of rind, colour of pulp, absence of seeds, and so on. These are eaten raw, and it is matter of congratulation, since all these are imported often from afar, that no fruits stand packing so well. Bitter oranges are greatly used for making marmalade, while the rind, rich in oil of orange, is dried and candied, and then known as orange-peel. Besides its use in cakes, puddings, and confectionery, orange-peel is a useful stomachic. The white portion underneath the rind is very indigestible, consisting almost entirely of cellulose, and contains a bitter principle, so that when oranges or lemons are wanted for flavouring, as in Russian tea or lemonade, the juice alone should be used or the white should be removed, leaving the yellow outer rind with its store of essential oils. Small unripe oranges, known as orange berries, are used in making curaçoa.

Lemons resemble oranges but are much more acid, containing as much as 7 to 8 per cent of citric acid, besides malic acid, sugar, and nitrogenous substances. They are therefore all the more valuable for allaying thirst, and for imparting pungency and flavour to tasteless fluids, such as rice and barley-water. Lemonade is made by adding a pint of boiling water to a sliced lemon and an ounce of white sugar, and digesting till

cold; or more speedily by squeezing a lemon and adding aërated water from a gasogene, so as to form "lemon squash". A spurious lemonade is often made by adding citric acid to water and flavouring with essence of lemon, and this becomes fraud when, instead of citric, tartaric and even sulphuric acids are used to give acidity. Lemon-peel is candied like that of the orange. Lemon-juice is highly esteemed in cases of rheumatism, since the citric acid in decomposing in the stomach oxidizes such elements as would tend to form uric acid, forming instead urea and carbonic acid, two substances capable of easy excretion, and so assisting metabolism.

The **Lime** is smaller than the lemon, and the juice extremely acid, containing about $32\frac{1}{4}$ grains of citric acid to the ounce. It is chiefly used in the shape of lime-juice as an antiscorbutic, and by the Board of Trade regulations the juice must have a specific gravity of 1030 without spirit, and contain at least 30 grains of citric acid to the ounce. To render its taste more agreeable, about half its own weight of sugar is added, then an ounce of brandy or whisky to every ten of juice, which addition gives it a greenish-yellow colour; then olive-oil is poured on the top to exclude air. The juice may also be preserved by boiling and sealing while hot without adding spirit at all.

The **Shaddock** and **Citron** are other trees of the citron tribe, and produce fruits similar to the orange, and used in a similar fashion.

Stone Fruits.—The *Plum*, *Bullace*, and *Sloe* are by many reckoned as distinct species, but others consider these last to be only varieties of the plum, like the *Damson* and *Green-gage*. They vary greatly in size, a single victoria or magnum bonum being equal to eight or ten damsons. There is no fruit so apt to irritate the digestive organs if eaten unripe, over-ripe, or in large quantity, colic and diarrhœa being the result. They are thus generally used in tarts or made into preserves, only the larger and sweeter sorts being served at table.

Damsons are more highly prized than plums for preserve-making, and are also used in damson-pies and damson-cheese, made like fig-cake. A special kind of plum grown in the south of France is even more indigestible, and forms when dried the medicinal prune. Common *Prunes* are dried plums, and are largely used in desserts, stewed and served with cream; they are often useful in removing habitual constipation. The ratio of sugar to free acid in plums is very low, 1·63 : 1; but in damsons, 7·03 : 1.

Apricots belong to the plum tribe, and there are over twenty varieties known, the finest being the Moorpark and Breda. This fruit does not keep well, and is therefore eaten fresh or used as preserves. Some varieties resemble sweet almonds in having a sweet stone.

Of all common fruits the *Peach* contains the least amount of sugar, 1·57 per cent, and is therefore specially useful for diabetic and gouty people. When the stone has been removed, the rest consists almost entirely of juice, since the solids amount to only 1 or 2 per cent. Peaches are esteemed for their juicy tender flesh, and their strong but delicate aroma; like most fruits they have a laxative action. The *Nectarine* is simply a variety of the peach, distinguished from it by its smooth skin, whereas the peach is velvety to the touch. Peach brandy is often made in the United States from inferior peaches.

The *Almond* is the type of the botanical class to which peaches belong. There are two kinds, bitter and sweet, the latter apparently obtained by cultivation. Sweet almonds have a very agreeable taste, and are fairly nutritious, being used in desserts and confectionery. Bitter almonds contain amygdalin, from which is obtained essential oil of almonds by a kind of fermentation, and since this contains a little prussic acid it has to be refined before use. Essential oil of almonds is used for flavouring and in making toilet soaps, as well as medicinally. When almonds are bruised they yield nearly half their own weight of a fixed oil, often given to new-born infants like castor-oil.

Cherries in this country are eaten fresh, stewed in tarts, or preserved; but in France and Germany they form a staple article of food among the charcoal-burners and wood-cutters, entering largely into soups. Cherry brandy is made by mixing brandy with cherry juice; Kirschwasser is a German liqueur made from cherries. Ripe wild cherries are freed of their stalks and bruised without breaking the stones. They are then allowed to ferment, and the kernels are broken and thrown in; the whole is now distilled, and kirschwasser is the result. Maraschino is prepared in like fashion from a fine delicately-flavoured variety; more care is taken to preserve the flavour, and only the finest sugar is used to sweeten it.

Dates are the fruit of the date-palm, which flourishes all over the north of Africa, and supplies food to millions of people from Morocco to Persia. They rank with grapes as a

high-class food-stuff, containing as they do 58 per cent of sugar and kindred substances. The fruit is eaten fresh or dried, and in the latter state it is made into flour. Solid masses of pounded dates are a familiar sight at every fruiterer's, and this is the regular storage form of food for the African caravans. Date stones are roasted and used to adulterate coffee, and an oil is also expressed from them when ground, the refuse being used for feeding cattle. Palm-wine is made by fermentation from the sap of the date-palm. The toddy-palm is generally regarded as the wild date; from its sap by boiling jaggery or date-sugar is obtained in the form of a syrup, 4 lbs. of syrup yielding 1 lb. of sugar. If this liquid be fermented, it forms palm-wine in the ordinary way and arrack by distillation.

The *Olive* is another stone fruit, much used in the south of Europe and the East, but little known here except for its oil. Pickled olives act as appetizers; the fruits are gathered before being quite ripe, and are steeped in lime-water to remove their disagreeable taste, then pickled in various ways. The taste for pickled olives is decidedly an acquired one.

Olive-oil occupies the first place among vegetable oils. It never gets rancid, does not dry, nor does it freeze at ordinary temperatures; is quite tasteless, and might be more largely used than it is in this country to the exclusion of cod-liver oil. At present it is only used for salad dressing. The oil is obtained from the lime-seed olive by pressure, the seeds yielding 58 per cent of olive-oil. It tends to become cloudy upon long exposure to light, as in a shop window, and is best kept in the dark. As a household liniment hot olive-oil has no rival.

Cotton-seed oil is now largely used as an adulterant, or even as a substitute, for olive-oil, and so excessively difficult is it to detect, that the Italian government have offered a prize for the best method of doing so.

Grapes.—The composition of the grape is as follows:—

Water, ...	... 78·17 per cent.	Non-nitrogenous extractives, ...	1·96 per cent.
Sugar, ...	... 14·36 „	Stones and cellulose,	3·60 „
Free acid,	... 0·79 „	Ash, ...	0·53 „
Proteids, ...	... 0·59 „		

With the exception of dates, grapes exceed all other fruits in amount of sugar, which is never below 12 per cent, and may be as high as 26 per cent. The ratio of sugar to acid in very good grapes is 29 : 1, and in ordinary seasons 16 : 1; in

unripe sour grapes 10 : 1. Even this last ratio is high, and one would expect such a fruit to be sweet, but in unripe grapes the extremely sour juice of the thick skin completely overpowers the sweetness of the grape itself, and in those grapes the juice is always sweeter than the whole fruit. The acid in grapes is mainly tartaric acid, combined with potash, lime, and magnesia.

When taken in excess they act as aperients, and the "Grape Cure" is vaunted for constipation, abdominal plethora, and other disorders to which persons of sedentary habits are liable. Patients on this cure begin with half a pound of grapes in the morning after rising, and another half-pound at 5 p.m. After two or three days another half-pound may be introduced between 11 and 12, then by degrees the dose is increased to about a pound each time. Pulmonary patients should not take more than 2 lbs. daily, and others should not exceed 4 lbs. For gastric catarrh 3 lbs. a day may be taken, the diet otherwise being carefully regulated. The effect of this cure is aided by a good supporting diet. Since the grape cure effects its best results when the patients take their own doses direct from the vines, and since this involves a fair amount of exercise, coupled with change of air and scene, it is questionable whether for such patients this or similar cure has any advantage over the sound democratic maxim—Live on sixpence a day *and earn it.*

Raisins are dried grapes, and are prepared in two ways. The finest, known as "Raisins of the Sun" or Muschatels, are dried on the growing plant by partially cutting the twig so as to arrest growth. The other method of drying, which produces Lexias, is more elaborate. The grapes are gathered and hung on lines, or laid in floors to dry in the sun. When dried they are dipped in a hot lye of barilla soda, to which is added a pint of olive-oil and $\frac{1}{4}$ lb. of salt for every four gallons. After being dipped in this, the raisins are drained and exposed to the sun for about a fortnight; they are then pulled from the stalks and packed for export.

The *Currant* is the raisin prepared from a small seedless grape grown in Greece. The name is a corruption of Corinths. Raisins are used in dessert and in cakes, while currants enter largely into tarts, puddings, and pastry generally.

Acid Fruits are represented by the gooseberry, cranberry, barberry, bilberry, and sloe. They are very refreshing, owing to the large amount of free acids in them, the ratio of sugar to

acid being about 3 : 1, so that they have to be eaten with sugar. They are chiefly used for tarts and preserves, or to furnish fruit syrups for aërated water. In sweet gooseberries the ratio of sugar to acid may be 6 : 1, in other varieties 4 : 1. Yellow gooseberries contain more soluble matters than red; when eaten freely they repel indigestion. Whortleberries include the bilberry, the Scottish blaeberry, the red whortleberry, often falsely called the cranberry, and the black whortleberry or huckleberry. Like the true cranberry, they are all intensely acid, and are used in tarts or made into wines. The bog whortleberry causes giddiness when eaten in excess. The barberry, when fully ripe, is quite sweet, and makes excellent jelly; when unripe and very acid it is used for tarts. It contains malic acid.

Fleshy Fruits: *Strawberry.*—Popular estimation of the strawberry is reflected in the saying, "Doubtless God could have made a better berry than the strawberry, but doubtless He never did". Says one enthusiast, and that too in a leading article:—"Its virtues are legion, and it has not a single defect. The gooseberry, like the rose, must be plucked from among thorns; the raspberry soon brings a warning sense of satiety; you may crush your teeth upon a grape-stone; and the biggest and sweetest apple has a core. But the strawberry is one unalloyed and unimpaired mouthful of deliciousness; it has neither rind nor stone to mar the perfect pleasure of the palate, and it is so healthful that you can eat it till you are tired. It is native, too, so that in swallowing it one may feel a virtuous glow of patriotism, such as no exotic delicacy can give, while its uses are almost as manifold as they are delightful. It is good when plucked fresh in the garden, better still when its rich red shows through the whiteness of cream and sugar, and when it is preserved there is, as Hood would have said, 'no *satis* to its jam'. Last, but not least of all, it is the earliest of our fruits, for Nature in its production seems to have imitated the host in the parable who brought forth his best wine at the beginning of the feast. The first strawberry, and not the first swallow, is the real and indubitable sign of summer, for when your tongue has touched it there rises the consciousness that in its essence is the whole spirit of June and July. A summer without strawberries would be worse than a Christmas without plum-pudding and mistletoe, but, fortunately, nothing so unseasonable is ever the doom of man in these latitudes. The sunshine may fail, but the strawberry

still makes its appearance; it seems to fear no phylloxera, and thrives in spite of hungry and predacious snails. An inhabitant of the temperate zone, it more than consoles us for the lack of plantains and bananas and guavas, which, after all, are not such delicacies as people imagine. When Macaulay returned from India he declared that he would give all the fruits of the East for a pottle of Covent Garden strawberries, and most other exiled Britons have doubtless been of the great historian's opinion." The ratio of sugar to free acid in strawberries ranges from 2 : 1 up to 6·7 : 1 in the pine-apple strawberry. They are richer than most fruits in potash and lime salts, and especially soda salts, and are thus recommended for gout. In moderation they are very wholesome and cooling. They have an agreeable aroma, and it is said that their flavour is enhanced by the addition of some acid juice, such as orange or lemon juice, or vinegar. After rain strawberries are comparatively insipid.

Raspberry.—In the wild raspberry the ratio of sugar to acid is only 1·8 : 1, but in cultivated varieties 3·5 : 1. Its uses are similar to other fruits of this class. Raspberry wine and vinegar are particularly agreeable and cooling in fevers.

The *Bramble*, *Blackberry*, or *Blackboyd* is by many people considered the finest fruit of this class, and yet it is rarely cultivated, probably because it is so abundant in the wild state. Seeing what cultivation has done for rasps, it seems a pity that the bramble is not taken up by gardeners. It is largely used for making wine, and bramble jelly is the finest jelly made.

Mulberries, red and black, are also used. The finest kind is the Indian mulberry. It is very refreshing and slightly laxative.

The *Fig* belongs to the same botanical order as the latter. It ranks with the date as a food-stuff, and is highly nutritious, since the pulp contains about 62 per cent of fig-sugar and 4 per cent of proteids. Figs are eaten green or sun-dried. The best figs come from Turkey, and inferior kinds are pressed along with almonds into fig-cakes, something like little cheeses. Dried figs are used medicinally to remove chronic constipation and in lung and kidney diseases, while their external use as plasters for boils and similar suppurations is of long standing, as evidenced by the case of Hezekiah.

The **Plantain**, of which the **Banana** is said to be merely a variety, was originally an Indian fruit, but shortly after the

discovery of America it was introduced there, and it now forms a staple food in all tropical countries. It is reported to yield a greater amount of food-stuff to the acre than any other plant, in this respect far excelling the potato in the ratio of 44 to 1, or wheat as 133 to 1, and it has the additional merit of needing little or no attention. Three dozen plantains are calculated to furnish as much nutriment as a week's supply of wheaten bread, chiefly in the form of starch and sugar. The smaller form of banana is generally eaten raw, or the pulp is pressed into cakes, which thus form saccharine loaves. Plantains are boiled, roasted, or baked in their skins like potatoes, or sliced and fried in butter and powdered with sugar, or the unripe fruit may be dried and ground into meal. It is used as a beverage like coffee, and may be fermented into wine; and when to these varied uses of the fruit there are added those of the other parts of the tree, it is not easy to name another vegetable which contributes so largely to human wants and comforts.

The *Pine-apple* is an example of a fruit which has been greatly improved by cultivation, the ordinary pine-apple being coarse and fibrous with little sweetness or flavour, whereas hot-house pines are among the most delicate and luscious of fruits.

The *Bread-fruit Tree*, a native of the South Sea Islands, belongs to the same family as the fig. The fruit is large, and has an outer rind, an inner core, and a white pulp, the last being the edible portion. It is cut to pieces, roasted, and eaten, and resembles new bread though tart, the flavour being compared to the crumb of white bread with a dash of Jerusalem artichoke. If kept long it becomes "high" and unpleasant.

The only **Nuts** that call for special notice are the chestnut, hazel-nut, walnut, and cocoa-nut. In Italy the *Chestnut* forms a valuable adjunct to the food-supply, and besides eating the nut fresh, there are three ways of preparing it—"ballotti" (boiled), "arrostite" (roasted), and "tegliate". In this last the nuts are shelled, boiled with caraway seeds for flavouring, so that the true chestnut flavour is wanting, and then mixed with maize-meal to make *polenta*. Another delicacy in the Apennines is *necci*, flat cakes made of chestnut-flour and water, without salt, owing no doubt to the tax on that article, and baked between hot flat stones with chestnut leaves between the cakes.

The ripe *Walnut* in this country is used in dessert, while the unripe fruit is pickled or made into walnut ketchup. In France, walnuts, just before they are ripe, are much used as a salad

with shallots, vinegar, salt, and pepper. The ripe fruit is one of the best of nuts, and on bruising it yields an oil which is also used as food.

The leading British nut is the *Hazel*, of which Cobs and Filberts are cultivated varieties. A great many nuts, valued at £100,000 in all, are imported annually from Spain and other countries, chiefly for the sake of their oil. Barcelona nuts are kiln-dried before export, and so keep indefinitely; when this is not done, hazel-nuts lose their agreeable flavour on keeping, and tend to become rancid unless kept in air-tight vessels.

Cocoa-nuts are used both for the food and drink obtained from them. The nuts are eaten both ripe and unripe by natives of the tropics, and each shell has at one end three holes, only one of which can be pierced so as to get at the "milk" inside. The resemblance of this end to a monkey's face is said to have given this nut its name, coco meaning a monkey. The white or kernel generally consists of nitrogenous material, but is indigestible in the highest degree. It contains fully 70 per cent of cocoa-nut oil or cocoa-butter, used not only for lighting and lubricating purposes, but also as a food. This contains from 60 to 70 per cent of fat, and from 23 to 25 per cent of organic matter. It is white in colour, has an agreeable taste, and is more digestible than dairy butter owing to its freedom from acid. It is suitable for cooking, and poor people prefer it for all purposes to margarine, while it is about half the price of ordinary butter in London. The process of making cocoa-nut butter was discovered by Dr. Schlinck, and it is now manufactured from cocoa-nut marrow by a Mannheim firm.

SUMMARY.

1. With few exceptions, fruits are not so much food-stuffs as refrigerants and antiscorbutics or blood-purifiers.

2. They all contain sugars, with a varying amount of free acid, tartaric, citric, or malic.

3. Plantains, dates, and figs are rich in sugary and starchy substances, and form the staple food of large populations.

4. Of home fruits the grape alone can be ranked as a food-stuff, especially in the form of raisins, on account of its amount of sugar.

5. Nuts are used either raw as food or for the sake of the oil expressed from them.

6. Practically, the only fruit oils used as food are olive-oil and cocoa-nut oil, the latter a solid oil like butter.

Lesson 37.—FOOD ACCESSORIES.

Under the name of Genüssmittel, or "means of enjoyment", as opposed to means of subsistence, the Germans include a great variety of substances, comprising most fruits and green vegetables, as well as beverages, spices, and condiments. Leaving for further treatment all beverages, alcoholic or not, this lesson may be confined to certain saccharine matters not fully treated in the lesson on sugar, as well as to those parts of plants generally used as spices or appetizers.

The relations of **Glucose** to cane-sugar have already been discussed, and it was shown that it is formed from the latter by "inversion" on long-continued boiling, or by the action of acids, resulting in a loss of sweetness, since glucose is only about three-fifths as sweet as ordinary sugar. On this account a little vinegar is added to cane-sugar when boiling syrup for bees, so as to imitate the mixture of dextrose and levulose found in honey. Although all carbohydrates are converted by digestion into dextrose, the latter is apt to cause acidity and flatulence if mixed with the food of dyspeptic persons, since it is easily decomposed and prone to set up acid fermentation. It is made from starch, and is used in large quantities for adulterating or even making honey, and for distilling, being readily fermentable. *Jaggery*, date-sugar or palm-sugar, is obtained from the sap of various palms. Glycyrrhiza or **Liquorice Sugar** is formed from the liquorice plant, and is grown in Surrey, as well as imported for the purpose of making porter. As Spanish juice it is a useful agent in catarrh of the throat, and it differs from ordinary sugar in neither fermenting nor crystallizing. As sold in the shops it is frequently adulterated; the best sticks are those stamped "Solazzi", and sold by weight.

Honey shows the following composition:—

Water at 100° C., ...	18·07 per cent.
Water above 100° C., ...	7·99 ,,
Levulose, ...	36·22 ,,
Dextrose, ...	37·58 ,,
Ash, ...	0·14 ,,

It is thus essentially a mixture of levulose and dextrose, but it contains in addition mannite or manna-sugar, wax, organic acids, pollen, alkaloid matters and bitters derived from plants

upon which the bees have fed, a small quantity of cane-sugar, and alcohol, the latter always present in natural honey. Honey is occasionally intoxicating; in Nepaul spring honey is avoided for this reason, and the story of its effects upon Xenophon's troops will naturally recur to the memory. In this instance the honey was derived from a species of azalea (*Azalea Pontica*); the flavour of Narbonne honey is due to rosemary, that of Hymettus honey in Greece to flowers of the labiate order, while in our own country the difference in weight, colour, and flavour between flower and heather honey is well known, the latter being the stronger of the two. Honey is largely adulterated by glucose syrup, as above described, and this "honey" may be sold as low as 2*d.* per lb. Since starch-sugar is made by the action of sulphuric acid on starch it has always from 15 to 20 per cent of unfermented substances, which may be detected in the polarimeter by their positive rotation, whereas natural honey, consisting largely of invert-sugar, shows a negative rotation. The ash left on igniting pure honey is always alkaline, and contains phosphoric acid, while honey made from glucose has a neutral ash. Not only is the honey itself often wholly or partly artificial, but our American friends show a misdirected ingenuity in making artificial honey-comb so as still further to delude the consumer. The cells are made of paraffin, and the *tout ensemble* looks even more inviting than pure honey. The fraud may be detected by sulphuric acid, which carbonizes ordinary wax, but not paraffin.

From Australia there has appeared within the last half-dozen years honey derived from the eucalyptus-tree. It is of a deep orange colour but transparent, generally solid in such a climate as ours, but syrupy in warm weather. It contains 62 per cent of sugar and 17 per cent of eucalyptus oil, so that it has the smell and flavour of eucalyptus essence, and it is thus valuable as a medicine. It is given in warm milk and water in doses of one or two tea-spoonfuls twice or thrice a day for bronchitis, asthma, and diseases of the lungs and respiratory disorders generally.

Mead is, or rather was, an English beverage made from fermented honey.

Molasses or **Treacle** is the name given to the residue of uncrystallizable sugar obtained in refining, and, as the undernoted analyses show, it contains a considerable amount of sugar, besides various bitters, which render it a stomachic, and far superior to syrup for most purposes. Owing to improvements in

sugar-refining much of the treacle sold now is thin and watery and very bitter—beet-sugar molasses are decidedly unpleasant, and are scarcely used as food—but the old-fashioned thick sweet treacle is still to be had, and for children who require a laxative, an occasional supply of treacle on a buttered slice of bread will be found all that is necessary, while a drop or two in baby's bottle will overcome the "hives" which commonly result from too rich feeding. Subjoined are analyses of various samples of treacle, quoted from Blyth.

	West Indian Molasses.	Treacle.	Golden Syrup.	Beet Molasses.
Cane-sugar, ...	47·0	32·5	39·0	46·7
Fruit-sugar, ...	20·4	37·2	33·0	·6
Extractives and colouring,	2·7	3·5	2·8	15·8
Salts, ...	2·6	3·4	2·5	13·2
Water, ...	27·3	23·4	22·7	23·7
Specific gravity, ...	1360	1430	1415	1405

Saccharin, discovered in 1879, is a remarkable substance which threatens to displace sugar for sweetening purposes, although it is not assimilated, and therefore not a food in any sense of the term. It consists of white crystals, soluble in hot water, alcohol, and ether, and is a derivative of benzene [C_6H_6], having the constitution $C_6H_4 \langle {}^{CO}_{SO_2} \rangle NH$. It is 300 times sweeter than sugar, and one part in 10,000 of water is perceptible to the taste. Its taste resembles sugar but with a peculiar flavour, and it is to be looked for in all sweet manufactured liquids, such as liqueurs, lemonade, &c., where it is often added to sugar to save the latter. It is also employed in jam-making, because cane-sugar sets up fermentation with the germs of the skins, and this action has to be annulled either by using excess of cane-sugar or by employing a higher temperature than usual; and both of these remedies injure the flavour of the jam. With saccharin in the proportion of $1\frac{1}{4}$ ounce to 4 gallons a temperature of only 180° F. is required.

Sweetmeats may be said to consist of cane-sugar, grape-sugar, or honey, together with flavouring and colouring matters. Sugar alone will give all shades of colour from pure white through yellow, orange, and red to brown and black, but vegetable colours are often used, and even aniline dyes have not

been proved to be injurious when pure. Sugar-candy contains 80 per cent of crystallized sugar, and a trace of uncrystallized sugar, which gives it its yellow colour, the rest being water. Toffy is sugar cooked with butter. Icing for cakes is white sugar mixed with albumen in the form of white of egg. Acid drops are flavoured with citric and other fruit acids, while peppermint drops consist of cane-sugar, albumen, and oil of peppermint.

Unless the sweetmeats are hard there seems no objection to them on the score of the teeth; the stomach is rather the organ to get out of order. Children naturally like sugar and detest fats, and it is a mistake to hide the sugar-bowl, good brown sugar being better for them than more highly refined forms, as treacle is superior to syrup. As already explained, the danger to the teeth arises from the fact that under the influence of the lactic acid ferment, always present in the mouth, sugary matters and carbohydrates generally are partially decomposed into lactic acid, which attacks the substance of the teeth, giving entrance to the fungus which causes caries. Children should be trained to use the tooth-brush with *cold* water *after* every meal, and in this way they will be saved a great deal if not all of the pain and expense which have in these days come to be regarded as inevitable.

Vinegar.—Among all the different condiments there is none so useful as vinegar, whether in the processes of cooking or for its action within the body. There are two methods of making vinegar, one by the destructive distillation of wood, giving rise to a form called pyroligneous acid, never used as food, and containing before refining several empyreumatic products, tarry matters, &c. The other process is by oxidation of alcohol, and is exemplified in the souring of beer or wine when exposed to the air, owing to the action of an aërial ferment which converts alcohol, first into an intoxicating substance, aldehyd, and then into acetic acid, one of the group of fatty acids. The word vinegar itself means sour wine, and to form wine or malt vinegar these liquors are exposed to the air at 77° for about a fortnight. As thus manufactured it contains generally 5 per cent of acetic acid, never less than 3 and often up to 6 per cent; besides this, colouring matter, and volatile ethers which communicate the special flavour of the different brands. The law also allows 1 part in 1000 of sulphuric acid, an addition which serves no useful purpose, and is rather to be deprecated on account of the tendency of sulphuric acid to form insoluble salts of lime

within the system; continental vinegar contains no such adulteration. Artificial vinegar is made from acetic acid coloured with caramel, but it lacks the volatile ethers which characterize pure vinegar.

Like other vegetable acids, vinegar is converted within the body into alkaline carbonates, and thus in moderate quantities, from half an ounce to an ounce daily, exercises an antiscorbutic action, but much inferior to lemons and limes. In moderation it allays thirst, checks excessive sweating, and aids digestion, especially the digestion of shell-fish and fish. Salads are much more digestible when eaten with vinegar, and the addition of a little is said to improve the flavour of many fruits. In large quantities it is undoubtedly injurious, interfering with digestion and often inducing gastric catarrh and other disorders of the alimentary canal; since it retards digestion it is often taken in various forms as a remedy for corpulence. It prevents the decay of animal and vegetable substances, and is used in this way for pickles; while in cooking fish, especially in hot weather, it is valuable not merely for its preservative action but for its chemical effects upon the muscles and bones of the fish, partly dissolving the latter and converting the flesh into acid albumen, thus anticipating the action of the stomach.

Mustard is an example of a condiment pure and simple, that is to say, it has no effect as a food nor in the chemistry of digestion, but simply stimulates the various glands, salivary, gastric, and others, so as to supply an increased flow of digestive juices. In the normal condition such stimulation is unnecessary; hunger is the best sauce, and the flavouring products developed in the processes of cooking are alone quite sufficient to act as appetizers. It is the old story of the crutches over again, and when the digestive organs have been whipped up in this way they cease to act unless in response to the stimulus, which thus becomes a necessity, stronger and stronger doses being required to produce the wonted effect, leading up to the fearful fiery combinations used to stimulate the jaded appetites of Anglo-Indians. Mustard owes its properties to an oil of mustard, which exists not as such, but as myronate of potash combined with a nitrogenous ferment, and from these on adding water the oil is gradually formed; the condiment should thus be made fresh for use so as to secure the full flavour. Although useful in small quantities, its use in excess leads to liver complaint. Pure mustard would be unpalatable, hence the commercial article is always diluted rather than adulterated

with starch; of course if this addition has been carried to such an extent that turmeric has to be added to restore the yellow colour, and cayenne to restore pungency, this would be considered as a distinct fraud. Its use in poulticing is well known, and a handy emetic is made by putting a table-spoonful of mustard in a tumbler of lukewarm water.

Pepper occurs as the natural berries in their dried and shrivelled state, called peppercorns; also as black pepper, consisting of the whole seed ground, and as white pepper, ground after removal of the outer husk. The best pepper comes from Malabar. It owes its properties to a volatile oil containing piperin, and more irritating than oil of mustard. Long Pepper is a similar plant grown in Bengal and used for pickling. Cayenne Pepper is a most irritating substance, and is derived from the pods of the capsicum plant. The red pods themselves, called chillies, are familiar objects in pickles.

Ginger is a root, or rather a rhizome or underground stem, and it thus contains starch. The young roots preserved in sugar constitute candied or preserved ginger, a good stomachic as well as a delicious sweetmeat. Ginger owes its properties to oil of ginger, and the solution of this in alcohol forms essence of ginger, much used in flavouring, and in making a spurious ginger-beer from syrup and aërated water. Real ginger-beer is produced by the fermentation of ginger roots and sugar with lemons, cream of tartar, &c., along with yeast in the usual way, then bottled before fermentation is complete. Ginger-wine is made like ginger-beer with the addition of spirit, and like all true wines it improves on keeping; cheap ginger-wines are flavoured with essence of ginger, or often with cayenne and other essences, including coal-tar products.

The physiological action of ginger and the following substances may be described as stimulating and **carminative**. The latter term is a convenient summary of various actions upon the digestive and vascular systems, generally due to the volatile and pungent oils in the substances employed. These rouse the stomach nerves, and so increase the activity of the circulation through that organ, exciting muscular contraction in it as well as modifying its contents. Possibly they relax the cardiac opening, at any rate eructation occurs, causing relief of stomach distension and its accompanying cramp and pain. At the same time, by the sympathetic ganglia of the digestive canal, and so through the spinal cord to the brain, a general effect is produced, and this is seen in a reflex action upon the

heart and blood-vessels, producing thus a general stimulation of the faculties, mental as well as bodily. Carminatives are thus one form of diffusible general stimulants.

Cinnamon is another aromatic. It is the bark of a small tree, and has been used from the remotest antiquity; it is mentioned in Exodus xxx. as one of the ingredients of the incense used in the Tabernacle service. The finest cinnamon comes from Ceylon, and the fragrance, especially in the thinnest pieces of cinnamon stick, is delightful, recalling the "spicy breezes that float o'er Ceylon's isle", while its taste is pungent and aromatic. Medicinally it is a tonic, stomachic, and carminative, owing its virtue to oil of cinnamon, and it has quite recently been extolled to the skies for its action as a disinfectant and germicide, while there may be some support for the statement that the comparative immunity from certain disease enjoyed by our forefathers was largely due their habit of using mulled wines and similar beverages, in the preparation of which cinnamon played a leading part.

Nutmegs and *Mace* are derived from the same plant, mace being the aril or investing membrane of the nut. Nutmeg is a stimulant and carminative, but in large doses it is narcotic, causing stupefaction and delirium, and should therefore not be taken in cases of brain disorder. Mace has very similar properties, having a peculiar strong smell and taste, due to a fixed as well as a volatile oil.

Cloves are the flower-buds of the plant, and derive their name from the French *clou*, a nail, owing to their shape. The buds are reddish at first, then deep brown, and are gathered and dried in the sun alone, or in the smoke of wood fires and then in the sun. About $\frac{1}{5}$ or $\frac{1}{6}$ of their weight consists of oil of cloves, and to this they owe their hot taste and characteristic smell, while medicinally they are used as stomach sedatives, to check nausea and griping after purgatives.

Pimento, *Jamaica Pepper*, or *Allspice*, the fruit of a small West Indian tree, gets its last name because the aroma resembles that of a mixture of cloves, cinnamon, and nutmeg. Like cloves it is a carminative, and useful in preventing nausea and griping. Its properties are due to a volatile oil, oil of pimento, used like oil of cloves in cases of toothache, and obtained by distillation with water. It forms the spirit of allspice or allspice water of the shops.

Caraway seeds are obtained from an umbelliferous plant. They act as carminatives and tonics, while oil of caraway is

given for flatulence. The seeds act as aromatic condiments, and are used for flavouring cordials, as well as in pastry and confectionery.

Coriander seeds are also carminative, and are highly aromatic. They are used in liqueurs and pastry or sugared, while in the north of Europe they are mixed with bread.

Vanilla is obtained from the pods of a parasitical orchid grown in Mexico and other sub-tropical countries. It is valued as a perfume, and the interior pulp is the most aromatic portion. It has a strong peculiar agreeable odour and a warm sweetish taste, and contains such an abundance of benzoic acid that the latter often effloresces in needle-shaped crystals. Vanilla is a gentle stimulant, and promotes digestion; in large doses it is a powerful aphrodisiac. The essence is used for flavouring chocolate and ices.

Curry, either as powder or paste, is a mixture of several aromatics, and two recipes are appended to show its composition:—

No. 1.

Turmeric powder, ...	6 oz.
Coriander-seed powder, ...	8 ,,
Black pepper, ...	4 ,,
Fenugreek, ...	2 ,,
Ginger, ...	2 ,,
Cayenne, ...	½ ,,
Cinnamon seeds, ...	½ ,,

No. 2.

Turmeric, ...	5 oz.
Coriander powder, ...	3 ,,
Black pepper, ...	1 ,,
Ginger, ...	1 ,,
Cayenne powder, ...	1 ,,
Scorched mustard, ...	½ ,,
Mace, ...	1 drachm.
Cinnamon, ...	1 ,,
Cardamoms, ...	2 drachms.

Along with the foregoing may be classed certain **aromatic herbs**, used for flavouring in various ways.

Parsley, one of the Umbelliferæ, is nutritious and stimulating as well as flavouring, and it owes its properties to an essential oil. It contains a peculiar gelatinous substance, apiine, and is sometimes made into jelly for invalids.

Sage is one of the Labiatæ, and the leaves only are used for flavouring dishes or in sauces. From the dried leaves and young shoots sage-tea is made, a popular astringent and tonic, while the oil of sage is used externally in rhuematism. The whole plant has a peculiar strong penetrating aromatic smell resembling camphor, and a bitterish aromatic, somewhat pungent taste.

Mint is cultivated in three varieties: spearmint, used for mint-sauce; peppermint, and pennyroyal. Peppermint is a powerful diffusible stimulant, often used to mask the taste of

drugs, and as an antispasmodic and stomachic to relieve wind in the stomach.

Thyme, also used for flavouring, and medicinally as a stimulant, possesses another aromatic essential oil.

Marjoram, another seasoning, is a stimulant and tonic, and is a remedy for nervousness. Its essential oil is a palliative of toothache, and is used, mixed with olive-oil, as a liniment in cases of rheumatism.

Dill, another of the Umbelliferæ, has a strong peculiar aromatic smell and taste. The leaves are used to flavour pickles and sauces, and the fruit in medicine; dill-water is a favourite carminative for infants. Its properties are due to oil of dill, and according to the old rhyme—

> "Mint, Saint John's Wort, Vervain, Dill,
> Hinder witches of their will".

Fennel belongs to the same order. The young sprouts from the roots are used in salads, while the leaves are boiled and made into sauces or served with mackerel, salmon, and other oily fish. Like garlic, it cannot be kept by simply drying and keeping in air-tight bottles. Fennel seeds powdered enter into compound liquorice powder, familiarly called Prussian powder.

SUMMARY.

1. Sugar derivatives are foods in proportion to the sugar they contain, while some, like treacle, contain in addition bitters which have a tonic and laxative action.
2. Vinegar behaves in the body like the vegetable acids.
3. Aromatics act as stimulants of the digestive organs, and as carminatives, owing these properties to their essential oils.

Lesson 38.—TEA, COFFEE, COCOA, &c.

Beverages may be conveniently classed under three heads:—1st, those depending for their stimulating qualities on some alkaloid—tea, coffee, cocoa, kola, and coca; 2nd, alcoholic drinks, subdivided into spirits, wines, and beers; 3rd, aërated and mineral waters.

Foremost among those of the first group stands **Tea**, obtained, as is well known, from the leaves of a shrub, not unlike a

camellia, grown originally in China, but now extensively cultivated in India, and more especially Ceylon. Two kinds are known to the market, black and green tea. The latter consists of tea-leaves naturally dried in the sun, thus preserving their green colour. It is a stronger tea than black, richer by 5 per cent, but excessive adulteration, "facing" with green colouring matter and so forth, has to a large extent destroyed public confidence in green tea, and black tea has now the market practically to itself. In black tea the leaves are allowed partly to decompose, and the black colour is due to this incipient decay due to fermentation.

The different trade names given to tea represent, not different varieties, but differences in the age and position of the leaves. The finest tea, made from the buds and young leaves at the top of the branch, is Orange Pekoe, the next leaves form Pekoe, the larger leaves, lower down, Suchong, and the older leaves, nearest the base, Congou. Generally speaking, the smaller the leaf the better the infusion, but tea is now commonly put into the market broken, both for the sake of packing and to convey a false idea of fineness or to increase the total surface exposed to the water. Broken leaves are easily detected by soaking in water and unrolling. "Lie tea" is a nickname given to rubbish made up with tea-dust, and coloured or faced to imitate the real article. It is not tea at all, and is detected by its poorness on infusion, a test which also indicates the presence of exhausted tea.

Analyses of tea differ very largely, but the following will give a fair idea of its composition, showing that apart from the sugar and cream added, tea contains practically no nutriment (König):—

Water, ...	11·49	per cent.
Nitrogenous substances, ...	21·22	„
Theine, ...	1·35	„
Ethereal oil, ...	·67	„
Fat, chlorophyll, wax, ...	3·62	„
Gum and dextrin, ...	7·13	„
Tannin, ...	12·36	„
Other nitrogen-free matters, ...	16·75	„
Woody fibre, ...	20·30	„
Ash,...	5·11	„

The important substance in these analyses is *Theine*, an alkaloid substance composed of carbon, hydrogen, nitrogen, and oxygen, and to it tea owes its stimulating properties. Combined with

theine so as to form a salt is *Tannic Acid.* There is a small amount of vegetable albumen, and the rest of the solids consist of vegetable fibre or cellulose, wax, resin, dextrin, &c., along with a volatile oil which may be called Tea Oil. It is this last which produces headache and giddiness in those who handle tea in bulk. The ash left on igniting tea is rather important, since the salts are mostly soluble, and consist of compounds of iron, manganese, and soda.

Tea is best prepared in a previously-heated teapot by infusion with water, boiling to coagulate the small amount of vegetable albumen present, as well as to extract as much theine as possible in a short time. Black tea yields to a first infusion from 29 to 45 per cent of its weight, average 38 per cent; green tea, which is a more active stimulant, from 40 to 48 per cent, average 43 per cent; or, dealing with the soluble matters alone, $\frac{6}{7}$ of these are taken up at the first infusion. Good tea should yield at least one-third of its weight in this way, and the Society of Public Analysts take 30 per cent as their minimum standard. All the salts and nearly half (47 per cent) of the nitrogenous substances pass into the infusion, this amount being increased by the presence of soda in the water.

The object of infusing tea at all is to extract the Theine, and leave the **Tannin** which is combined with it. Tannin is precipitated by gelatin and albumens, but in tea it is combined with the theine, and this combination has first to be broken up. Under these circumstances it is impossible to get an infusion free from tannin, and all that is aimed at is to reduce the quantity of this substance to a minimum. On this point the quality of the tea is an important consideration, certain teas being richer in tannin than others; the quality of the water used, soft or hard, plays an important part; and generally it may be said that any given tea must be treated on its own merits, requiring a certain quality of water and a certain time of infusion to give the best results, and the precise combination must be worked out by trial. The experiments of Dr. Hale White (*Brit. Med. Jour.*, August 1889) are exceedingly instructive on this point. The figures below show the percentage of tannin obtained from representative teas:—

	Finest Assam.	Finest China @ 5/.	Common Congou.
3 minutes' infusion, ..	11·30	7·77	9·37
15 do. do.	17·73	7·97	11·15

This shows conclusively that with a high-class China tea the proportion of tannin extracted is not appreciably increased by the longer infusion, but that in a cheap tea prolonged infusion is to be avoided. The figures also demonstrate the large excess of tannin found in Indian (not Ceylon) teas, and the large increase, nearly $\frac{2}{3}$ more, due to length of infusion. Infusion is accelerated when the leaves are broken, so as to present a larger total surface, and but for risk of adulteration tea-dust would give almost perfect results in this respect. The Chinese Brick Tea and the Japanese Tea Powder are applications of this, and within the last year the well-known chemists, Burroughs and Wellcome, have prepared tabloids of compressed tea which seem to prove very useful to those who want a hurried cup. They are sold in boxes of 100 for 6d, and, according to the makers, one tabloid is sufficient for a tea-cup, but, unless for those who like strong tea, this is an overestimate. The great advantage of these to nurses, district visitors, commercial and other travellers, &c., is obvious, and the employment of them conduces to economy, since the exact number of tabloids is taken each time. The residue in the cup consists of the insoluble matters, chiefly cellulose. Various devices have been employed to reduce the risk of extracting too much tannin, generally taking the form of removing the leaves from the water when the time-limit has been reached. The time-honoured "cosy" stands condemned in this respect, though if the tea be infused in one tea-pot and transferred to another heated vessel, then the latter may have its temperature maintained by any suitable means without any risk of extracting more tannin. Water containing much iron and lime would require to be well boiled with carbonate of soda before infusing, so as to remove both these substances as carbonates as well as to soften the water. The following experiment may be commended to those who, by reason of excessive breakages, have been driven back upon "tin" tea-pots, really made of iron plated with tin:—Make a strong infusion of tea, boiling it indeed so as to extract as much tannin as possible, and then add a few drops of a ferrous salt such as copperas; the tea becomes almost black from the formation of a tannate of iron, in plain English—*ink*, since ink is formed by the action of tannic or gallic acid upon iron salts. This will perhaps explain the very peculiar colour which tea assumes when infused in a well-worn tin tea-pot, and will give some idea as to the probable effect of iron medicines taken immediately before or after tea. If for

domestic reasons a strong pot is wanted, there can be no objection to the use of enamelled steel, taking care that the enamel inside is not chipped or otherwise impaired.

The physiological **effects of tea** comprise its general action on the nervous system, and, locally, its inhibitory effect upon the salivary and other diastatic secretions. Dealing first with the latter, it is undoubtedly the case that tea retards or even arrests both the salivary and pancreatic digestion of starches, and this inhibitory effect is due to the tannin rather than the theine, for even a 2-minutes' infusion will produce the same results. Roberts recommends the addition of a little dry baking-soda, 10 grains to an ounce of tea-leaves, and this, besides softening any hard water, entirely neutralizes the above effect of tannin on the digestive juices, as well as correcting the acid dyspepsia which often accompanies the use of strong tea. A still better plan, and one calculated to give the full benefit of the theine, is to follow the example of the Chinese, and drink tea *between* and not *at* meals; the best time would be 1 to 2 hours before a meal after the heavy work and worry of the day. To get the best effect of tea the Chinese example should also be followed in respect of sugar and cream, since when these are added tea becomes in virtue of them a food-stuff in the proper sense. Regarded in this light, the popular "meat tea" is a physiological mistake. In the so-called "digestive" tea the tannin has been so altered by electrical treatment as no longer to precipitate gelatin or interfere with the digestion of carbohydrates.

Theine, the other constituent of tea, from which it derives its stimulating properties, belongs to the group of alkaloids of which strychnine and nicotin are the other extreme. They all act on the nervous system, form crystalline salts, and behave chemically like ammonia. In ascending order of vigour they are:—

1. Acting feebly on the nervous system: Theine or Caffeine, Theobromine.
2. Acting more powerfully: Quinine.
3. Powerful stimulants, producing paralysis in larger doses: Morphia, Atropin.
4. Producing paralysis in small doses: Strychnine, Curare, Nicotin.

Theine or caffeine, for the two substances are identical, along with theobromine, the special alkaloid of cocoa, acts upon the central nervous system as a gentle stimulant, it soothes the worried man, relieves him of his cares, removes his fatigue, and clears his brain. The skin is stimulated to increased

action, and in this way hot tea may exercise a *cooling* effect just as in the case of alcohol. These alkaloids are powerful antidotes to alcoholic poisoning, and perhaps this explains the customary cup of strong coffee which closes a public dinner. Strong coffee is a well-known remedy in cases of laudanum or opium poisoning, on account of the wakefulness it produces, and the student who wishes to steal a few hours from the night in view of a coming exam. knows how to utilize this property. Taken in excess tea or coffee will produce sleeplessness, nervousness, palpitation of the heart, and muscular tremors, &c., and when such effects follow the offending cause should be at once removed. In many cases the appearance of such nervous symptoms marks a season of undue excitement and worry from other causes, and when these external circumstances change for the better the subjective symptoms change with these. In the *British Medical Journal*, June 1888, Surgeon W. T. Black blames tea for loss of teeth, alleging that its excessive use leads to inflammation and abscess of the roots.

To sum up:—Tea is a valuable stimulant for persons who need stimulating, the soldier on the march, the cyclist on tour, the business man struggling with competition, the elderly man whose energies are flagging, the commercial whose dinner-hour is an unknown quantity, to ladies exhausted by shopping, and, shall we add, to the shop-girls more exhausted still in that process; but for children, whose energy needs the brake rather than the whip, for the man whose hours are regular and meals assured, indulgence in these alkaloids, even tea, the weakest of them, is but adding one more useless habit to a nature already too little free.

Coffee comes from a shrub, the *Caffea arabica*, and is the seed stripped of its coverings and dried. For consumption the berries are further prepared by *roasting*, an operation which should be postponed till the last moment. In roasting, at 210° C. or over, the berries lose 15 to 20 per cent of their weight, chiefly in water, though about half their caffeine is also expelled; they become dark-brown, and the small amount of natural sugar in them is converted into caramel. At the same time the heat disassociates caffeine from the caffeo-tannic acid in which it existed, and also develops the peculiar volatile oil which gives to coffee its characteristic aroma. Since this oil is very volatile, the roasting must neither be too severe nor too prolonged—the best temperature is 210° C.

—and the coffee should be ground and used immediately after roasting, failing which there is always a loss of this aromatic oil, in spite of closed tins and other devices. Roasting further renders the berries light and porous, owing to the escape of gases, chiefly nitrogen and the oxides of carbon; this swells the berries, and so, though larger, they are light; ground coffee floats on water, while chicory sinks.

The essential constituents of coffee are theine or caffeine, already described in connection with tea, caffeo-tannic acid, generally combined with potash, the peculiar volatile oil, and coffee-butter. The relative proportion of these is shown in the following tabular analyses (Blyth):—

Sample.	Gummy matters.	Caffeine.	Fat.	Tannin and Caffeo-tannic Acid.	Cellulose.	Ash.
Finest Jamaica, ...	25·3	1·43	14·76	22·7	23·8	3·8
Finest Green Mocha,	22·6	0·64	21.79	23·1	29·9	4·1
Ceylon, ...	23·8	1·53	14·87	20·9	36·0	4·0
Washed Rio, ...	27·4	1·14	15·95	20·9	32·5	4·5
Costa Rica, ...	20·6	1·18	21·12	21·1	33·0	4·9
Malabar, ...	25·8	0·88	16·80	20·7	31·9	4·3
East Indian, ...	24·4	1·01	17·00	19·5	36·4	4·0

When coffee is made by infusion, under the boiling-point as with tea, there is extracted only 19 to 25 per cent, whereas we ought to obtain from 30 to 35 per cent. The British are blamed for being the only civilized people in the world who cannot make coffee, and perhaps the false analogy of tea, for the preparation of which they are famous, has led them astray, for the error is twofold—too little coffee is used to begin with, giving a wishy-washy solution, and it is prepared by infusion like tea. To obtain the full strength of the coffee the example of the East should be followed, and the beverage prepared by infusion and decoction combined. This is effected by first making an infusion as with tea, but the grounds are boiled in more water, and this boiling fluid poured over a second portion of fresh coffee. Prepared in this way, coffee should yield fully one-third of its weight of extract, while the aroma is conserved as much as possible.

Like tea, coffee is not a food, except for the milk and sugar added to it, and when coffee is prepared by using boiling milk instead of water, as in café au lait, its food value is, of course, considerable. Although the percentage of caffeine is less in

coffee than in tea, there is really more consumed, owing to the greater strength of the beverage, and this attains a maximum in café noir.

The physiological **effects of coffee** are similar to those of tea, though the latter acts on the peripheral nerves, while coffee acts rather on the nerve-centres. Caffeine and theine are the same substance, but in coffee the caffeine is combined to form caffeo-tannic acid, a substance not so inhibitory of carbohydrate digestion as tannin alone. Since coffee is usually taken of a greater strength than tea, it has a stronger effect upon the stomach, and is apt to produce heartburn after a full meal, especially if taken as café noir. Like tea it excites the skin and also the kidneys, so that the excretion of urea is increased; it has an aperient action on the bowels, and strongly affects the muscular system, renewing its vigour. It is this quality which causes it to be prized by cyclists, pedestrians, and others who have a large mechanical output, and Parkes extols it as against alcohol for army use. "Not only is it invigorating without producing further collapse, but the hot infusion is almost equally serviceable against cold and heat; in the one case the warmth of the infusion, in the other the action on the skin, being useful, while in both cases the nervous stimulation is very desirable" (*Practical Hygiene*, p. 352).

Negro Coffee, sometimes called Mogdad Coffee, is prepared in a similar way from Fedegozo seeds (*Cassia occidentalis*), a plant grown in the West Indies and in the west of Africa. Its analysis shows the following composition:—

Olein and margarine, ...	4·9	per cent.
Tannic acid, ...	0·9	„
Sugar, ...	2·1	„
Gum, ...	28·8	„
Starch, ...	2·0	„
Cellulose, ...	34·0	„
Water, ...	7·0	„

Its properties are due to the colouring matter, achrosine, which forms 13·58 per cent of the ash, and consists of carbon, hydrogen, nitrogen, oxygen, and sulphur. As will be seen, it contains no caffeine, and much less tannic acid than coffee, but it is largely used for adulterating coffee; and it is said that neither in appearance nor taste can such mixture be detected, if the proportion of negro coffee does not exceed one-fifth. Owing to its purgative properties it is sometimes called small senna, but these properties, due to the muci-

laginous matters, extractive and chrysophanic acid, are destroyed by roasting. It has a distinct febrifuge action, and a solution of 1 in 10 of water boiled down to 9 is given in the cold period of a rigor in paroxysmal fevers such as ague. Mohammedan writers recommend it for coughs, especially whooping-cough, and in Brazil it is used in dropsy and liver complaints as a tonic and diuretic, its action in the latter respect securing for it the name sometimes given by children to the dandelion.

There are in the British market several **coffee substitutes**, such as "French" coffee, Date coffee, &c., the names of which are very misleading. Under the Food and Drugs Act a packet labelled "Coffee" must consist of pure coffee, but whenever the word "coffee" is qualified by some other word, such as "prepared", "French", &c., a mere fraction of coffee may be present without infringing the law. Thus French coffee has often three-quarters of its weight of date stones, acorns, or even roasted beans, added to chicory; and a "prepared" coffee may largely consist of starch and brown sugar. It is greatly to be desired that mixtures should have stamped on the packet the percentage of coffee in them, if the name coffee is to be used at all, for with best coffee at 1*s.* 8*d.* the pound, and chicory at 5*d.*, it is easy to see that a person who likes his coffee with a dash of chicory may be paying a coffee price for a chicory article. The most common adulterant is **Chicory**, and, as already mentioned, many people prefer coffee with a chicory flavour. It differs from coffee chiefly in having neither caffeine, tannin, nor volatile oil; it is much richer in sugar, having from 10 to 18 per cent, whereas good coffee has never more than 1 per cent; and it is further darker in colour and much heavier. The difference of weight may be used to detect adulteration; pure coffee floats on water or sinks slowly, chicory sinks rapidly. Since chicory is the *root* of the chicory plant roasted and ground, its microscopic appearances are such as characterize roots, showing vascular bundles, spiral vessels, and the like. "Dandelion" coffee is prepared by roasting dandelion roots; like chicory it is used to adulterate coffee, and as a household medicine.

Cocoa is classed with tea and coffee in virtue of its peculiar alkaloid theobromine, "food for the gods". It is prepared from the seeds of the *Theobroma cacao*, deprived of their outer pulp and roasted, in which process, as in the coffee-bean, the starch of the seed is changed into dextrin. The fresh cocoa has an oily and rather bitter taste, but on being "sweated" or

fermented like black tea this unpleasant flavour is removed, and there is developed instead the peculiar aroma of cocoa, due to an aromatic oil. The crushed beans form the "nibs" of commerce, and when rolled they form "flake cocoa". As will be seen from the following analysis by König, cocoa differs widely from tea and coffee:—

Water, ...	3·25	per cent.
Nitrogenous, ...	14·76	„
Fat, ...	49·00	„
Starch, ...	13·31	„
Other non-nitrogenous, ...	12·35	„
Cellulose, &c., ...	3·68	„
Ash, ...	3·65	„
Theobromine, ...	1·6	„

The striking feature of this analysis is the large amount of fat, constituting half the total weight. This fat is called cacao-butter, and consists chiefly of cacao-stearin with a little olein; it has the property of not becoming rancid however long it is kept, but the presence of other fats impairs this. About one-fifth of the total proteid matter is indigestible, so that cocoa depends for its food-value upon its fat and starch, since the amount of theobromine is small and its action as a stimulant slight. When taken in excess theobromine appears in the urine. Cocoa thus ranks as a food-stuff of no mean order, and this is the more important since by most methods of its preparation the solid cocoa is consumed, not left behind like tea-leaves and coffee-grounds. Cocoa is rendered "soluble" by removal of the woody fibre and other insoluble matters, but in this, as in all commercial cocoas, there is a large addition of sugar and starch. To a certain extent this preparation—it can hardly be called adulteration—is defensible, for so large a proportion of fat is too much for most digestions, while the addition of sugar further obscures the bitter taste found in Caraccas cocoa owing to the fermentation process. Either by direct removal or by making up with starch and sugar, the proportion of fat is reduced by at least one-half, the minimum S. P. A. standard being 20 per cent. The following comparison of commercial cocoas will give a good idea of the various methods of preparation:—

Epp's cocoa	=	cocoa 40%, sugar 44, starch 16.
Granulated cocoa	=	cocoa-nibs + arrowroot + sugar.
Homœopathic cocoa	=	cocoa-nibs + arrowroot.
Maraville cocoa	=	cocoa + much sugar + sago flour.
Cocoatine	=	pure cocoa, less 60 to 70% of fat.

In Dutch cocoa, typified by Van Houten's, the fat is not removed but rather saponified and so pre-digested, by soaking the cocoa-beans in water containing potash or soda. The advantage of this process is seen in the fact that this cocoa may be prepared by simply adding boiling water or milk, whereas if a large amount of starch be present the cocoa must be boiled to dissolve this.

Chocolate is cocoa specially prepared from the finest quality of cocoa-nibs and sugar, flavoured with aromatic substances, generally vanilla. The process may be seen in many a chocolatier's shop-window, and consists in crushing the cocoa-nibs in a mill under heated rollers. This process softens the cacao-butter, and this last forms with the sugar and flavouring a paste which is then pressed into moulds. A few trade recipes are appended:—

French chocolate: 2 beans of vanilla rubbed into a powder with sugar, and 1 lb. of sugar to 3 of cocoa-nibs.

Spanish chocolate: Curaçoa cocoa 11, sugar 3, vanilla $\frac{1}{16}$, cinnamon $\frac{1}{64}$, cloves $\frac{1}{128}$.

Spanish chocolate (another recipe): Caraccas cocoa 10, sweet almonds 1, sugar 3, vanilla $\frac{1}{64}$.

Vanilla chocolate: Caraccas cocoa 7, Mexican vanilla $\frac{1}{16}$, cinnamon $\frac{1}{32}$, and cloves to flavour.

Vanilla chocolate (another recipe): Chocolate paste 21, vanilla 4, cinnamon $\frac{1}{8}$, cloves and musk.

The subjoined analyses by König will illustrate the transition from cocoa to chocolate:—

	Cacao Beans.	Chocolate.
Water,...	3·25	1·53
Nitrogenous, ...	14·76	5·06
Fat, ...	49·00	15·25
Starch, ...	13·31	—
Sugar, ...	—	63·81
Other non-nitrogenous,	12·35	11·03
Wood fibre, ...	3·68	1·15
Ash, ...	3·65	2·15

Deserving to be classed with the above beverages, but far behind in commercial importance, are other three substances, Maté or Paraguay or **Holly Tea**, Coca, and Kola. The first of these is a shrub of the holly tribe, growing to the height of nearly 20 feet, and cultivated extensively in Paraguay, the

Argentine Republic, and S. Brazil. The beverage is prepared from the leaves, with the young shoots and branches, by a double roasting which develops a peculiar aromatic oil. The leaves, &c., are then powdered, pressed, and sun-dried, infused like tea, and the infusion sucked through straws. Holly tea contains about $\frac{1}{2}$ per cent of theine, and a peculiar kind of tannin which does not tan hides. In its action it resembles tea and coffee, but is slightly narcotic in excess. It is extremely refreshing and restorative, especially after great fatigue; has a slight but pleasant bitter taste, and thus acts as a tonic stimulant, and exercises a beneficial action on the internal organs generally. Another kind of holly is used in Virginia in the same way as maté.

Of recent years the public have become familiar with two substances which belong to this class, kola and coca. The former is made from **Kola** nuts, and is greatly lauded for its fatigue-resisting power, especially if chewed raw or taken freshly ground. It contains theine, and acts as a nervous stimulant. The special properties of kola are due to its colouring matter, kola red or kolanin; it acts as an antidote to alcohol-poisoning, and in virtue of the mucilaginous matter it contains it clarifies beer, spirits, and impure water. Kola paste and cocoa form a chocolate ten times more nutritious than Caraccas chocolate, and when mixed with a low-class cocoa in the proportion of 1:3 it greatly improves the latter in strength and flavour. In nitrogenous substances kola is superior to tea, coffee, and cocoa, containing five times as much theine as tea. Its flavour is sweet at first, then astringent, finally bitter, but the bitterness nearly disappears in the dried nut, reappearing on soaking in water. Kola is very pleasant in the form of chocolate, flavoured with sugar and vanilla.

Similar to kola in its power of taking away the feeling of fatigue is **Coca**, obtained from the leaves of a Peruvian plant. It acts best when the leaves are chewed, and its value as a restorative has been demonstrated by experiments made in the German army. From the leaves is obtained its active principle cocaine, so much used now as a local anæsthetic in eye and tooth operations.

SUMMARY.

1. Tea, coffee, cocoa, and similar beverages owe their stimulating properties to an alkaloid, theine or caffeine, and theobromine.

2. With the exception of cocoa, they are not food-stuffs at all, but nerve stimulants.

3. Tea and coffee contain tannin, which acts as a retarder of digestion, and all methods of preparation aim at extracting as little tannin as possible.

4. The active principle of tea and coffee is theine or caffeine, a nerve stimulant, but invigorating the muscles and the body generally, and producing, if taken in excess, sleeplessness, nervousness, and palpitation.

5. Cocoa contains a large amount of fat and starch, and is, besides, consumed with the beverage, ranking thus as a high-class food-stuff.

6. Its alkaloid, theobromine, is present in smaller quantity than the theine of tea, and is, besides, a much feebler stimulant.

7. Chocolate is cocoa with the addition of sugar and vanilla or other flavouring.

8. Kola and coca have similar properties to tea and coffee.

Lesson 39.—ALCOHOLIC DRINKS.

Before discussing alcoholic beverages it may be advisable to learn something about **Alcohol** itself. Like sugar, alcohol is the name, not of a single substance, but of a class of substances produced by the partial oxidation of paraffins, but the only alcohols commonly met with are ethyl alcohol or spirits of wine, methyl alcohol or wood-spirit, and amyl alcohol or fusel-oil. Alcohols all consist of carbon, hydrogen, and oxygen, and, as is seen by a spirit-lamp, burn away without residue, forming carbonic acid gas and water. They have a characteristic spirituous smell, mix in all proportions with water, evolving heat in the process, and from this mixture they can only be recovered with some difficulty, so great is their affinity for water. They are all lighter than water, the specific gravity of ethyl alcohol being ·7938, water being 1, and it boils at 78·3° C. (water at 100°). The lowness of the boiling-point is often forgotten in recipes for dishes into which alcohol enters, although perhaps it is not a bad thing that complex Christmas dishes should thus unwittingly have three-quarters of their alcohol dissipated by heat. When water is added to alcohol the specific gravity of the mixture rises, and elaborate tables have been drawn up so as to enable an analyst to determine the alcoholic strength of a solution by the hydrometer alone.

When the proportion of water is such that the mixture at ordinary temperatures has $\frac{12}{13}$ of the weight of an equal bulk of pure water, it is called "proof spirit", and spirits weaker or stronger than this are called under or over proof. A spirit 30 U.P. means 30 of water + 70 of proof spirit; 20 U.P. means 20 of water + 80 of proof spirit; whereas 25 O.P. means that 25 parts of water require to be added to reduce this spirit to proof strength. Proof spirit is, roughly, half and half of alcohol and water, the exact proportions by weight at 10° C. being, alcohol 49·24, water 50·76. A mixture of proof-strength should just manage to ignite gunpowder if kindled.

Since the boiling-point of alcohol is so much below that of water, it may be separated from its solution in the latter by distillation; this gives Rectified Spirit, containing about 80 per cent of alcohol, and when rectified spirit is further distilled, first over dry lime and then over sodium, substances which readily abstract water, the result is absolute alcohol, 100 per cent, though, as bought at a chemist's, it rarely contains over 95. Pure alcohol thus obtained has a burning taste and a spirituous odour; it reddens the skin and tongue, hardens animal tissue, and so arrests decay; hence zoological specimens are often preserved in alcohol. Its effects upon albumen may be seen by breaking an egg into spirits of wine; the albumen is coagulated, and in a few minutes converted into a cheesy indigestible mass.

Methylated spirit is spirits of wine mixed with 10 per cent of methyl alcohol or wood-spirit, a red mixture which does not impair its usefulness in the manufacture of varnishes and polish, while rendering its taste sufficiently nauseous to prevent its consumption as a beverage. Of recent years, and to check increasing illicit consumption, the taste has been still further modified by the addition of mineral oil.

Amyl alcohol, or fusel-oil, is heavier than the other two, and has a much higher boiling-point (130°). On this account it is the last product of distillation, and it is formed when spirit is made from grain or potatoes instead of malt. The effect of amyl alcohol is produced when 3 grains are taken, so that anything like $1\frac{1}{2}$ grains of this to the ounce would condemn a whisky as injurious on this ground alone. As a rule, it may be said that the poisonous properties of alcohols increase with their weight.

There are two processes for making alcohol, **distillation** and brewing, but in both cases the starting-point is starch. Some

grain, such as barley, is moistened and gently warmed to encourage germination, a process which develops the full activity of diastase, the natural malt extract of the grain, and this acting on the starch converts it into maltose or sugar of malt. When sprouting has begun, the heat is increased to arrest further growth, and the grain, now called Malt, is found to be darker in colour and much sweeter. This is now put into the mash-tub and thoroughly extracted with water, which dissolves or washes out all sugary or starchy matters, and this is fermented with yeast, as in brewing. At this point the distillery and the brewery part company. In distillation the "mash" is heated in a closed copper still at the proper temperature, and the volatile matters are condensed as they come over, and collected in the following order:—"Foreshot", methyl alcohol, ethyl alcohol, water, higher alcohols. The product is generally re-distilled to get rid of lower and higher alcohols, and to leave if possible only spirits of wine and water. As thus prepared, a spirit, say whisky, is colourless, but custom demands various conventional shades of yellow and brown, and these are obtained by the addition of caramel.

In **brewing**, on the other hand, the process is completed by the action of various organized ferments, wine and beer yeast. The yeast fungus lives upon sugar, converting ordinary sugar and maltose into glucose or fermentable sugar, and then decomposing part of the latter into alcohol, giving off carbonic acid gas in the process, and forming at the same time small quantities of glycerine (3 per cent) and succinic acid as bye-products. The process may be indicated by a chemical equation thus:—

$$\underset{\text{maltose}}{C_{12}H_{22}O_{11}} \overset{}{\underset{\textit{and}}{+}} \underset{\text{water}}{H_2O} \underset{\textit{form}}{=} \underset{\text{"invert-sugar", \textit{i.e.} dextrose and levulose.}}{C_6H_{12}O_6 + C_6H_{12}O_6}$$

$$\underset{\text{glucose}}{C_6H_{12}O_6} \underset{\textit{forms}}{=} \underset{\text{alcohol}}{2C_2H_6O} \underset{\textit{and}}{+} \underset{\text{carbonic acid gas.}}{2CO_2}$$

Only a part of the sugar originally present in the solution is converted into alcohol, since the yeast plant is killed when the proportion of alcohol rises above a certain limit; thus wine yeast is unable to live in 14 per cent of alcohol, so that if wine shows 20 per cent of alcohol—and wines for the British market nearly all do so—the extra spirit has been added. This behaviour of yeast is merely an extreme case of the action of putrefactive germs, and in all cases of putrefaction alcohol is produced in minute quantities from animal matter, as well as by the living cells of the body.

If any alcoholic liquor produced by fermentation, say beer or natural wine, be exposed to the air, further oxidation takes place, as described in lesson 37, and first aldehyd and then vinegar is formed under the influence of the acetic-acid bacillus. The successive changes may be represented chemically thus:—

$$\underset{\text{alcohol}}{C_2H_6O} \ \textit{and}\ \underset{\text{oxygen}}{O} \ \textit{form}\ \underset{\text{aldehyd}}{C_2H_4O} \ \textit{and}\ \underset{\text{water.}}{H_2O}$$

$$C_2H_6O + O = C_2H_4O + H_2O$$

$$C_2H_4O + O = C_2H_4O_2$$

aldehyd *and* oxygen *form* acetic acid.

The first effect of the oxidation is to remove the equivalent of hydrogen required to form water, hence the name Aldehyd, *i.e.* *Al*cohol *de hyd*rogenated. This substance is very intoxicating, and is invariably produced in new wine, hence the allusion in Acts ii. 13. As the equations above show, it is easily oxidized in turn, producing acetic acid, so that there is a regular chain of substances all connected by the different transformations as follows:—Starch—sugar (cane-sugar, maltose)—glucose—alcohol—aldehyd—acetic acid. The word vinegar means sour wine, and the Germans call acetic acid Weinsaüre.

Alcoholic beverages are commonly classed as spirits, wines, and beers, the last two being fermented liquors, the first products of distillation. Parkes gives the following comparison of spirits:—

Spirit.	Alcohol.	Solids.	Ash.	Acidity per ounce (as Tartaric Acid).	Sugar
Brandy, ...	45 to 55%	1·2	·05 to ·2	1 grain.	0 or traces.
Gin,.........	49 to 57	1·2	·1	·2	1
Whisky, ...	50 to 55	0·6	trace	·2	0
Rum, ...	50 to 60	1·0	·1	·5	0

Spirits are now simply flavoured alcohol, and consist of ethyl alcohol, ethers derived from this in the process of "mellowing", water, and certain colouring and flavouring substances. The leading European spirits are brandy, whisky, rum, and gin, all obtained by distillation from fermented saccharine liquids as already described.

Brandy (German, *Branntwein*, distilled wine), Cognac or Eau-de-vie, is, or perhaps it would be more correct to say was,

distilled from fermented grape-juice, for since the ravages made in French vineyards by the phylloxera, pure cognac is exceedingly rare, and most of the brandy in existence is simply potato spirit or grain spirit. The starch of these is converted into sugar by extract of malt, yeast is added, and the fermenting mixture distilled at 78·3° C., the boiling-point of alcohol. The colour of brandy may be due to caramel, but is often imparted by storing the liquid in oak casks; this extracts a large amount of tannin, and so far condemns the liquid owing to the action of tannin on digestion. Although brandy has long been regarded by medical men as the finest form of alcohol, it is very questionable whether, to avoid adulteration, a good malt whisky would not be preferable, all the more as it is only inferior brandies which are coloured by caramel. Most of the brandy made in Britain is artificial, being made from argol, plums, &c., by distilling with grain spirit and adding tannin, acetic ether, and caramel to imitate the colour and flavour.

Whisky contains 50–55 per cent of alcohol, and is made from barley malt, grain, or starch. Scotch whisky is made from malt mash, Irish from malt and grain, no sugar being used; new whisky is pot-still whisky. In the old days of the "sma' still" barley malt was exclusively used, but the introduction of patent stills and the extended scale of manufacture has increased the amount of potato and grain spirit, and it is in these spirits from unaltered starch that fusel-oil is found. When whisky is allowed to mature, the fusel-oil decomposes into bodies comparatively harmless, and there are also developed at the expense of the alcohol various ethers which, as in the case of brandy, impart a characteristic flavour. In Scotland and Ireland the "smell of peat-reek" is imparted by drying the grain over peat fires. As already mentioned, good malt whisky is more likely to be pure than brandy, and it has the advantage of being much cheaper. The drink sold by illicit traders in shebeens and low public-houses is generally of a very vile description, made from questionable material and crammed with injurious products.

Rum, a spirit containing 50–70 per cent of alcohol, is in the West Indies distilled from fermented molasses, though inferior kinds are also made from the débris of the sugar-cane left in the mills. On the Continent rum is also made from beet-molasses. It is the strongest of our spirits, rising up to 90 per cent, and is the only one which contains a little sugar.

Rum is the favourite nautical drink, though it is being displaced by coffee and cocoa, and no better proof of physiological ignorance and misplaced confidence could be obtained than that afforded by the "rush for rum" which characterized the great frost of 1895. A mixture of 2 parts of rum to 1 of glycerine is very valuable for sore throat and bronchial affection.

Gin or Hollands is a corn-spirit flavoured with various substances such as juniper berries, coriander seeds, &c. Since the grain is unmalted, the spirit must be freed from fusel-oil by redistillation, and thus prepared it has an alcoholic strength of from 49 to 57 per cent. Unlike the other spirits it is not coloured, and the presence of oil of juniper or any similar oils causes a milkiness when it is diluted with water, since these oils are insoluble in water. Oil of juniper acts on the kidneys like oil of turpentine, and so causes gin to increase the flow of urine. Gin is often sold sweetened by sugar.

Of other spirits in use on the Continent and in the East, the following are the most common:—

Arrack, containing 50 per cent of alcohol, is made from the fermented juice of the cocoa and other palms; cheaper forms from fermented rice mash.

Kirsch or Kirschenwasser, as the name implies, is made from cherries or plums.

Toddy is got from palm juice; *Vodka*, a Russian spirit, from potatoes. Spirits are also extracted from maize, maple, millet, and many other vegetable products.

Liqueurs, in the French sense, comprise all spirituous drinks artificially formed, whether by fermentation and distillation like rum, kirsch, gin, or by flavouring spirits with aromatic substances so as to produce curaçoa, anise, absinthe, &c. The English use of the name is confined to this latter class, and a liqueur may therefore be defined as spirit and some aromatic flavouring. Of these the best known is *Absinthe*, a spirit which in France takes the place of gin in England. It is a greenish liquid, containing, like most spirits, 50 per cent of alcohol, and having as its essential flavouring oil of wormwood, derived from the *Artemisia Absinthium*. There is generally $1\frac{1}{2}$ per cent of sugar and about $2\frac{1}{2}$ per cent of other essential oils, such as those of aniseed, angelica, cinnamon, cloves, and peppermint. As in the case of gin, these oils are precipitated on diluting the liqueur with water. Absinthe owes its green colour to vegetable green or chlorophyll, obtained from nettles, parsley, spinach, or other plants. The

effect of absinthe upon the body is much stronger than that of alcohol simply, owing to the poisonous effects of oil of wormwood.

As examples of representative liqueurs, simple and complex, there are appended a few recipes, taken from trade formulæ.

CURAÇOA.

Spirit of Curaçoa, ...	8 litres.
Alcohol at 85°	17 ,,
Sugar, ...	$12\frac{1}{2}$ kilos.
Water, ...	66 litres.

ANISETTE.

Spirit of Anise, ...	5 litres.
Alcohol at 85°	20 ,,
Sugar, ...	$12\frac{1}{2}$ kilos.
Water, ...	66 litres.

Size with white of egg, and filter.

Noyeaux is flavoured with apricots; Ratafia, with black currants; Peppermint cordial, with peppermint water.

GREEN CHARTREUSE.

Dried lemon balm, ...	500 grams.
Hyssop in flower, ...	250 ,,
Peppermint dried, ...	250 ,,
Genepi, ...	250 ,,
Balsamite, ...	125 ,,
Angelica seeds, ...	125 ,,
Angelica roots, ...	62 ,,
Thyme, ...	30 ,,
Arnica flowers, ...	15 ,,
Buds of balsam poplar, ...	15 ,,
China cinnamon, ...	15 ,,
Mace, ...	15 ,,
Alcohol at 85°	62 litres.

Digest for twenty-four hours, then distil and rectify up to 60 litres. Add 25 kilos. of refined white sugar dissolved by the aid of heat in 24 litres of water; mix, and make up with water to 100 litres. Mellow and colour green by a mixture of blue colouring and infusion of caramel or saffron. Size, allow to settle, and filter.

SUMMARY.

1. Alcohol is derived from fermented sugar solutions either by fermentation alone or by distillation.

2. It is composed of carbon, hydrogen, and oxygen, and burns without residue, forming carbonic acid gas and water.

3. It has a great affinity for water, and therefore hardens animal tissue, acting as a preservative.

4. Spirits are produced by distilling starchy or sugary infusions, and contain generally 50 per cent of alcohol.

5. Liqueurs are spirits flavoured with vegetable essences.

Lesson 40.—WINES.

Wines may be described as fermented grape juice, either in its natural condition, or with the addition of alcohol to preserve it or to attain a conventional standard. When grapes are crushed, the must thus formed comes under the influence of a kind of yeast in the air, *Saccharomyces ellipsoideus* or wine yeast, which acts upon it much as brewer's yeast does upon malt mash, the chief difference being that in the case of wine the fermentation is spontaneous. Unripe grapes contain a little malic acid, the acid characteristic of apples, but the ripe fruit and the must made from it contain tartaric acid. From the fermented mass there is obtained on evaporation a reddish powder called argol, really impure potassium tartrate, and it is from this that the ordinary tartaric acid crystals are prepared.

The effect of wine yeast is to convert some of the natural grape-sugar into alcohol, evolving carbonic acid and forming certain by-products. The more sugar the more alcohol, and hence, in bad seasons, glucose is often added to must before fermenting. The quantity of sugar also depends upon the treatment of the grapes before pressing; thus *vins secs*, as Tokay, are prepared from grapes partially dried on the stem before plucking, *vin de paille* is made from grapes sun-dried on straw, and both of these yield wines of high alcoholic strength. Very ripe grapes may furnish a juice containing 40 per cent of sugar, whereas in Holland, where the weather is not so settled as in the wine countries, the percentage of sugar is only 10 or 12. As in brewing, there is formed a little aldehyd, highly intoxicating, but soon oxidized into acetic acid. The red colour of certain wines is due to a pigment contained in the skins, and in red wines this is retained by keeping the skins, while in white wines they are removed. On standing, red wines tend to deposit their pigment, thus becoming lighter in colour. Connected with the seeds in the must is the presence of tannin, which may be present in such quantity as to cause

astringency; this is of course a defect, for, as has been seen in the case of tea, tannin has a retarding influence upon digestion. In old port the tannin may separate out, thus giving the wine a "tawny" colour.

When the wine yeast has converted a certain amount of grape-sugar into alcohol, its action is arrested, stoppage of fermentation occurring when the alcohol forms not more than 14 per cent of the liquid. The average percentage of alcohol in natural wines is 7 or 8; but in order to preserve certain wines of low alcoholic strength, as well as to satisfy the demands of the British palate, the wine is "fortified" by the addition of spirit, so as to fetch the strength up to 20 or even more. If all the sugar of the juice has been converted into alcohol, the wine is proportionately less sweet, and is said to be "dry" as opposed to "fruity". Some of the Hungarian wines contain a very high percentage of sugar, as much as one-fifth, while the sweet wines of Greece, as well as some ancient wines, are almost syrups. Generally speaking, the more sugar the less acid, and, on standing, the sugar gradually disappears, being changed by the action of the free acid into invert-sugar.

On long standing there are formed at the expense of alcohol various ethers, caproic and caprylic ether, and other odorous bodies, often called in the mass œnanthic ether, and it is these substances which give their peculiar flavour and bouquet to special wines, and the predominance of which gives the first place for delicacy to Hungarian wines. As is invariably the case when alcohol is formed by fermentation, carbonic acid is given off, and if a wine be bottled when this action is all over, the product is a "still" wine; if, on the other hand, the wine is bottled, like beer, before the fermentation is quite over, then the liquor becomes charged with carbonic acid gas, which effervesces on liberation, producing a "sparkling" wine. Sparkling wines may also be made on the principle of aërated waters, by passing carbon dioxide into wine under pressure.

A natural wine is comparatively poor in alcohol, and thus readily undergoes the acetic fermentation; but since the acetic bacillus cannot live in a highly alcoholic liquid, or in absence of air, all that is necessary to preserve those of a lighter kind is to exclude air, or add a germicide such as salicylic acid. The latter is the course generally adopted in unfermented wines, and to keep light fermented wines olive-oil is poured on the liquor in the cask so as effectually to exclude air.

The natural salts of grape-juice consist chiefly of cream of

tartar or potassium hydro-tartrate, often deposited as a crust upon casks and bottles, as well as lime tartrate, phosphates, and sulphates. The presence of lime and sulphuric acid is largely due to the vicious habit of "plastering", another concession to a false criterion of purity. Every natural wine is slightly muddy, but the connoisseurs have decreed that wine shall be transparent, and in order to obtain the required clearness gypsum or plaster of Paris is added. This has two results: a fine precipitate is produced, which carries down most of the mucus and albuminous substances that offend the eye, along with a certain amount of tartaric acid removed in combination with the lime, leaving in its place sulphate of lime, for plaster of Paris, which is sulphate of lime, is slightly soluble in water. It is this sparingly soluble salt of lime which is largely responsible for the amount of gout due to the use of wine; natural grape-juice, or natural wine, like most fruit juices, rather tends to get rid of such obstructions within the body. Sherry wines especially are most liable to be adulterated in this way, and in order to restore the œnanthic ether affected injuriously by "plastering", recourse is had to further adulteration. An additional source of sulphuric acid is to be found in the process of "sulphurizing", specially applied to sweet white wines which tend to decompose easily. Sulphur is burned in the casks to fill them with sulphur dioxide, and then the wine is poured in. Sulphur dioxide is an antiseptic and so checks acetic fermentation, but it is exceedingly soluble, and by oxidation becomes sulphuric acid.

The following table from Neubauer illustrates the transition from must or grape-juice to wine:—

Must.	Wine.
Water, ...	Water.
Grape-sugar, 13 to 40 per cent, ...	Less grape-sugar; alcohol, 7 to 14 per cent.
Albuminoid bodies, ...	Small residue of albuminoid bodies, acetic and succinic acids.
Cream of tartar, ...	Do., but in smaller proportions.
Tartrate of lime, ...	
Vegetable mucus, ...	Removed by plastering.
Gums,...	Gums.
Malic acid, ...	Do., especially from unripe grapes.
Salts of ammonium and similar bases,	——
Colouring matter, ...	Do.
Organic acids, ...	Do.
Mineral matters, ...	Do.
	Glycerin, tannin, œnanthic ether, a few yeast cells, &c.

It may be summarized as follows, apart from alcohol and its by-products:—A diminution of mucilaginous and sugary matters; a diminution of those substances insoluble in water, but soluble in must, such as sulphate and phosphate of lime; and a diminution also of cream of tartar, magnesium tartrate, and potassium sulphate, which are less soluble in alcohol than in water.

When wine is kept in cask or in bottle for a long time important changes take place. The tannin and colouring matter are generally deposited, leaving the liquor tawny and comparatively lighter in colour. The sugar also diminishes, and in very old wines all the cane-sugar becomes invested by the action of the fruit acids, rendering the wine less sweet. Glycerine and the œnanthic ethers increase, the latter at the expense of the alcohol and the tartaric acid, so that the wine may be only three-fourths as acid as when new. Wine that has been long in bottle has sometimes a peculiar flavour, and is said to be "corked"; the cause of this is a mould which grows on the outside of the cork but penetrates to the inner surface.

Most of the cheap wines imported into this country are artificial, being made at Hamburg, Cette, &c., from cider or ordinary potato and grain spirit, flavoured with œnanthic ether, and coloured by aniline dyes or by vegetable extracts like madder, beet-root, and logwood. As an example the following is a Russian recipe for making "port":—Cider, 3000; kino, 8; old hock with cider, 3000; brandy, 1000; nitric ether alcoholized, 8. For the detection of these impurities elaborate schemes are given in analytical works.

The so-called "British wines", ginger, currant wine, &c., as sold in the shops, are not wines at all, but simply forms of grog coloured to suit, and flavoured with different essences generally having not the remotest connection with the fruits they simulate. Of course a real wine may be made, and often is made, by fermentation as in the case of the grape, but these wines are generally made only for household use.

One must place in quite a different category the real British wines, viz. cider, perry, and mead. The last is honey wine, made from honey and water by fermentation in the usual way. It is rather a liqueur than a wine, being deficient in acids, ethers, and salts, and therefore merits the condemnation of Pliny, who said it had all the bad qualities of wine and none of the good ones. It is a thinnish liquid, very rich in sugar, and effervescent.

Cider is properly apple wine, and is so called in Germany. It is extensively made in Devonshire and Worcester district in England, and in Normandy and the United States, and is prepared from acid or bitter apples. The apples are bruised in a mill, and the pulp pressed through hair-cloth sieves. The apple-juice thus got is a dark-coloured, sweetish liquid, and is set aside in casks to ferment naturally. In a few days the clear liquid is decanted off, and must be bottled, since it does not keep very well, being converted into "hard cider" owing to the formation of lactic acid. Cider contains from 5 to 9 per cent of alcohol, and so far resembles beer rather than wine. The acid in it is not tartaric but malic acid, and this gives it an aperient action. Cider differs from beer in having neither bitters nor malt extract, and is proportionately less nourishing, but it forms a very cool refreshing drink in summer. **Perry** is pear wine, and is made in Worcester and Devon, forming with cider the chief beverage of these districts. It is made from pears which are rather sour for eating, and like cider contains from 5 to 9 per cent of alcohol, being therefore intoxicating when drunk in large quantities.

The analyses of wines on p. 233 are given by König.

Beer is an alcoholic liquor produced by the artificial fermentation of malt as already described. It is thus distinguished from wine, in which fermentation is natural and produced by Saccharomyces ellipsoideus, whereas in beer the brewer adds the yeast, a form of the class *Saccharomyces cerevisiæ.* The process of brewing has been already described, and all that is necessary here is to add a few details. There are two methods of inducing fermentation, depending on the kind of yeast used. In Britain, and formerly on the Continent as well, "Top" yeast (Oberhefe) is added to an infusion of malt, and fermentation is carried on at a moderately high temperature, 15 to 18° C. (60–66° F.); the yeast in this process floats as a scum on the top, and is skimmed off as occasion requires. Throughout Europe this process has now been almost entirely discarded in favour of the use of Low yeast (Unterhefe), a result due to the researches of Pasteur. In studying the subject of fermentation Pasteur found that the high temperature at which ordinary brewing was conducted encouraged the growth of "wild" yeasts and other micro-organisms, and these gave rise to acid fermentation, ropiness, muddy appearance, bitter taste, and other deleterious effects. To secure uniformity of results he recommended the employment of low yeast, which flourishes

	Alcohol.	Free Acid.	Sugar.	Tannin, Colouring, &c.
Red Wines.				
Rhine (mean), ...	10·08	·52	—	·16
Hungarian, ...	9·65	·59	—	·13
Burgundy, ...	11·15	·53	—	?
Bordeaux, ...	9·07	·59	—	·22
White Wines.				
Rhine, ...	11·45	·46	·37	—
Moselle, ...	12·06	·61	·20	—
Riesling, ...	12·90	·65	·01	—
Sweet Hungarian, natural.				
Tokayer Ausbruch, '66, ...	12·74	·52	14·99	18·34
Ruster " '72, ...	11·08	·51	21·74	23·64
Fortified Wines.				
White Port, '60, ...	20·03	·54	4·88	8·83
Red " '65, ...	21·91	·45	6·42	8·83
Sherry, '70, ...	22·90	·44	1·88	3·78
Madeira, '70, ...	19·11	·48	3·46	5·22
Marsala, ...	20·44	·39	3·48	4·94
Malaga, '72, ...	16·14	·42	16·47	21·23
Sparkling Wines.				
Champagne, ...	11·75	·58	11·53	13·96
Rhine, ...	12·14	·57	8·49	12·14

at a temperature too low for most others to live or at least to thrive, and thus in low-yeast fermentation the operation is conducted at a much lower temperature, 4 to 5° C., maintained in small breweries by suspending in the fermenting decoction inverted metal cones containing ice, in the larger establishments by causing a current of cold air to circulate around the fermenting tanks. Low yeast is much heavier than ordinary yeast; it thus sinks to the bottom and the clear fluid is decanted, still containing some particles of yeast, and in this way there is induced an "after fermentation", which makes the beer very brisk owing to the extra amount of carbonic acid gas generated in it. The Faro and Lambick beers of Belgium are fermented naturally like wine, the process lasting for weeks; they therefore contain many "wild" forms, and there is a good deal of acid produced, chiefly lactic acid, rendering them "hard".

The essential substances in beer are four in number—extractives, and sugars, bitters, free acids, and alcohol. The follow-

ing table quoted by Willoughby affords a comparison of several beers:—

Name.	Malt Extract.	Alcohol.	Carbonic Acid.	Water.
Porter (Barclay & Perkins), ...	6·0	5·4	·16	88·44
Burton Ale, ...	14·5	5·9	—	79·6
Edinburgh do., ...	10·9	8·5	·15	80·45
Berlin do., ...	6·3	7·6	·17	85·93
Brussels Lambick, ...	3·4	5·5	·2	90·90
„ Faro, ...	2·9	4·9	·2	92·0
Munich Bock, ...	9·2	4·2	·17	86·49
„ Lager (16 mos.), ...	5·0	5·1	·15	89·75
„ Schenk (draught), ...	5·8	3·8	·14	90·26
Brunswick do., ...	5·4	3·5	—	91·1
Prague do., ...	6·9	2·4	—	90·7
Brunswick sweet beer, ...	14·0	1·36	—	84·7
Brown beer, Berlin, ...	3·1	2·3	·3	94·2
White beer do.	5·7	1·9	·6	91·8
Bière blanche, Louvain, ...	3·0	4·0	—	93·0

König gives the following as the mean of several analyses:—

	Albumen.	Malt Extract.	Alcohol.	Carbonic Acid.	Water.	Ash.
English Ales and Porter,	·73	6·32	5·16	·21	88·52	·27
German Export or double beer, ...	·71	7·23	4·07	·25	88·72	·27
Do. summer beer, ...	·49	5·61	3·68	·22	90·71	·22
Do. winter beer, ...	·81	4·99	3·21	·23	91·81	·20

In virtue of its malt extract and sugar beer may claim to rank as a food-stuff, and as such certainly not less valuable than potatoes. The original barley contains about $\frac{2}{3}$ of its weight of starch, and about $\frac{1}{3}$ of this becomes sugar in the process of malting, while the rest is transformed by fermentation, so that the percentage of sugar in beer is pretty high. Since carbohydrates are readily available as a source of energy, they are more easily consumed within the body than proteids or even fat, and this is seen in the tendency of beer-drinkers to accumulate fat, a result not found in spirit-drinking.

The use of pure malt is declining in this country; it is said that of the great breweries there are only two that use pure

malt, and most brewers add large quantities of sugar, either as such or in the form of molasses.

The bitter principle in beer was originally derived from hops, and in Bavarian beer no other bitter is allowed, and the hops, moreover, must be sun-dried, whereas in Britain they are kiln-dried and bleached by the fumes of burning sulphur. The active principle in hops is lupulin, and the peculiar drowsiness observable in beer-drinking is due to oil of hops. British law allows other **aromatic bitters** as hop substitutes, and gentian, quassia, calumba, and others are extensively used in this way. The physiological action of these substances is much the same; as their name implies they stimulate the sense of taste, and by reflex action not only induce a greater flow of saliva but excite the stomach secretions as well. On being swallowed, they act directly on the stomach and cause a sensation like hunger, thus rousing the appetite, while at the same time the local circulation and the heart are stimulated, thus producing a "tonic" effect. It is evident that if food is not taken shortly after a bitter, the auxiliary effect of the latter is so far thrown away. Many of these substances contain tannin, and thus they stimulate the bowels, arresting fermentation and so removing flatulence, while evacuating the bowel. They are therefore of great service in dyspepsia, or in cases where, owing to overwork or similar exhaustion of energy, the digestive process cannot be properly carried on. Of all the bitters, calumba is perhaps the least irritating, but if taken in excess or without any cause they lose their effect, and the stomach finds itself unable to proceed without its accustomed spur. Within the last two or three years a great many teetotal beers have gained public confidence under the name of hop bitters of various kinds. They are all infusions of malt or other sugary substances, but aërated by carbonic acid gas under pressure, and they owe their bitterness to hops or some of its substitutes. To these there can be no objection whatever on the score of alcohol, and their use is rapidly extending.

All beers contain free acid, generally carbonic, and in the case of the Belgian naturally-fermented beers, lactic acid as well. When beer turns sour, a thing rarely possible in "low" fermentation, the acetic acid developed makes it hard. These acids, acetic and lactic, form alkaline carbonates within the body, and in this way, like the vegetable acids generally, they maintain the blood in its natural condition.

Of all alcoholic drinks beer contains the least amount of

alcohol, the proportions ranging from $1\frac{1}{2}$ per cent in Brunswick sweet beer, a liquor with which intoxication is a physical impossibility, up to the strong British beers, as represented by Bass's and M'Ewan's, containing from 7 to $8\frac{1}{2}$ per cent. In order to increase its intoxicating properties, and so give an appearance of greater alcoholic strength, cocculus indicus is often added. German beers are much less alcoholic than British beers; some of them, indeed, contain so little that they are intended for immediate consumption only. Lager beers are stronger, while Bavarian beer, made under stringent regulations, has a deservedly high reputation. The quality of water used has an important influence on beer; only the best spring water is used, and thus beer shows on evaporating and igniting a small percentage of ash. Common salt is often added to beer to induce thirst, and sugar to increase the "head" of froth and give an appearance of greater aëration.

Stout is a beer in which a darker colour has been produced by the addition of roasted malt; it is therefore proportionately more nutritious than ordinary ale, though more liable to adulteration. **Porter** is another British mixture of dubious composition, containing often liquorice, treacle, linseed, &c. These drinks are often used by nurses to increase their supply of milk, but their action in this respect is entirely fallacious, as already explained in the lesson on milk.

There are two examples of what may be called milk beers, viz. Koumiss and Kefyr, the alcohol in which is derived from the fermentation of milk-sugar, in the former case from mares' milk, in the latter from cows'. **Koumiss** is prepared for invalids in forms of different alcoholic strength, ranging from 1 to 3 per cent, and contains besides all the milk products and lactic acid, the casein being in the granular condition and therefore readily digested, while the slight amount of alcohol, too small to intoxicate, serves to stimulate the gastric secretions. It is frothy and milky-looking, not unlike milk and soda, with a slightly acid taste, and the following is given as its composition after two days' fermentation:—

Alcohol, ...	1·65	per cent.
Fat, ...	2·05	"
Lactose, ...	2·20	"
Lactic acid, ...	1·15	"
Casein, finely divided, ...	1·12	"
Salts, ...	0·28	"
Carbonic acid, ...	0·70	"

For further details of the "koumiss cure", which is specially intended for cases of phthisis, the student is referred to Burney Yeo's *Food in Health and Disease*, p. 519.

Kefyr is prepared in a similar fashion in the Caucasus from cows' milk, and since this contains less sugar than mares' milk the beverage is proportionately less alcoholic.

Physiology of Alcohol.—The effects on the body of excess of alcohol are very marked, especially when it is habitually taken on an empty stomach. As is seen by the egg experiment, excess of alcohol coagulates fresh proteid matter, and thus when taken into the stomach it inflames the mucous membrane, causing gastric catarrh. Its effect upon the liver is greatly to increase the interlobular connective tissue at the expense of the liver substance, thus producing "gin-drinkers' liver". Fatty degeneration in the liver and the muscular system generally bears witness to the disturbance of nutrition set up by alcohol, and this symptom is specially observed in the heart. The blood-vessels also are affected, and are thus more liable to rupture, causing apoplexy and similar disorders; and general interference with nutrition is indicated by the presence of such diseases as gout, stone, gravel, characterized by the retention of waste products within the body or by retrograde changes.

Alcohol acts through the sympathetic nervous system upon the heart and the surface circulation. The heart-beat is quickened and the surface capillaries filled with blood, so that the skin flushes and a feeling of heat is experienced. It is only a feeling, however, for a thermometer held in the mouth shows a fall in the temperature, and the reason is apparent: if more blood than usual is sent to the skin, the body loses heat by radiation. Since the circulation is stimulated the muscular system is temporarily excited, but the stimulus is fleeting and supplies no real energy. In this respect alcohol is in marked contrast to coffee, which imparts new energy to the muscles, acting upon them through the central nervous system. The action of these may be further contrasted:—alcohol lowers the temperature of the body, coffee raises it; alcohol stimulates the heart and blood-vessels, especially the surface blood-vessels, in a fugitive way, coffee imparts a fresh store of energy to these; alcohol interferes with tissue change and thus diminishes waste, as shown by the lessened output of urea and carbonic acid, coffee either leaves metabolism unaffected or slightly increases the excretions; lastly, strong coffee is an antidote in cases of alcoholic poisoning.

It is this influence of alcohol on metabolism, its power of interfering with tissue-change, which forms the sole rational ground for its employment. In small doses it may be valuable as a means of saving the tissues in wasting diseases, for it is so readily oxidized into water and carbonic acid that it saves the materials of the body from being drawn upon, thus earning its reputation among French dietetists as a "*moyen d'epargne*".

All this, however, is true only if the use of alcohol be restricted within the physiological maximum. It is generally agreed that under ordinary conditions the body cannot assimilate more than 1 ounce or at most 1½ ounce of pure alcohol per day, and as spirits generally contain 50 per cent of alcohol, this would mean 2 ounces (a gill is 5 ounces) of whisky, &c., or of strong wine from ¼ to ½ pint, of light wines or strong beers from ½ pint to a pint, and of continental beers about a pint and a half. All above this is *excess*, and has a distinctly injurious effect upon the body, and yet how few there are, men who would not like to be called even "moderate drinkers", who confine themselves to these limits. The truth is, that whatever excuse men make to others for indulging in alcohol, the real motive is literally a psychical one, they take it because they like it, and one of the most damning indictments against alcohol is the moral cowardice which it produces, for it affects all the faculties, beginning with the highest. It begins by quickening the judgment and imagination, then dulling them, the lower centres of speech, sight, taste, and hearing are next affected, then the centre of co-ordinated muscular movements is paralysed and the person staggers in his gait, later on the motor centres are altogether paralysed and the person becomes "dead drunk", last of all this paralysis affects the centres of involuntary movements, such as those of the heart and lungs, and this produces alcoholic insensibility ending in death. Landois and Stirling (4th edition) give the following summary of the effects of alcohol in small doses, within the physiological limit:—

1. 95 per cent is oxidized, forming water and carbonic acid. This takes place very readily, and in this way alcohol may be a substitute for tissue consumption, since decomposition of proteids is diminished by it to the extent of 6·7 per cent. The odour of the breath is due to small quantities of volatile substances, fusel-oil, &c., contained in the liquor, and not to alcohol itself.

2. Small doses excite, large doses paralyse the nervous system, beginning with the higher centres.

3. Alcohol diminishes the sensation of hunger, and so is of great use in temporary want.

4. It excites the vascular system, accelerates the circulation, and therefore the muscles and nerves are more active because of their greater blood-supply. In large doses the vessels are paralysed, thus becoming dilated, resulting in a fall of the bodily temperature.

SUMMARY.

1. Wines consist of grape-juice naturally fermented.
2. Natural wines contain from 7 to 10 per cent of alcohol, never more than 14 per cent.
3. Wines for the British market are "fortified" till they contain 20 per cent and more of alcohol.
4. Red wines owe their colour to the retention of the pigment in the grape-skins.
5. Sparkling wines have been bottled before the completion of fermentation.
6. Cider is apple wine, but contains malic instead of tartaric acid.
7. Beer is made by the fermentation of malt or sugar, and contains 5 to 8 per cent of alcohol in this country, on the Continent 2 to 5 per cent.
8. Beer contains a considerable proportion of food-stuffs, often 14 per cent, in the shape of sugar and malt-extract.
9. The physiological limit of alcohol is $1\frac{1}{2}$ ounce of absolute alcohol per day; within this it is valuable for tissue-saving purposes, but outside of that is injurious.

Lesson 41.—AËRATED AND MINERAL WATERS.

Amongst non-alcoholic beverages must be included the large class of waters, charged either naturally or artificially with carbonic acid and other gases, and the simplest of these is the so-called **Soda Water**. Ordinary drinking-water is really aërated, and when its air has been expelled by boiling the water thus treated is comparatively insipid, hence distilled water as made in the condensers of ships has to be aërated in various ways in order to become palatable.

On a large scale the carbonic acid gas is generated from limestone or marble chips by means of hydrochloric acid, thus

forming as by-products water with common salt in solution. The gas is forced into the bottles previously filled with water from which the air has been expelled by boiling. If this is not done, on uncorking the liquid is apt to spurt violently and get lost. The colder the water the more gas it will dissolve, and under ordinary conditions water can dissolve five times its own bulk of carbon dioxide. Of recent years very pure carbonic acid has been obtained from the vats of breweries, where it was a waste and sometimes a noxious product.

For household purposes gazogenes are coming very largely into vogue, and they need no description. The materials used are baking-soda and tartaric acid, the exact proportions being 8 : 7, or nearly 3 ounces altogether for a 5-pint gazogene, and the by-product, retained in the upper compartment, is acid tartrate of soda, resembling cream of tartar. Any solid acid substance may be used instead of tartaric acid, such as citric acid, cream of tartar, acid sulphate of potash, and so on. Ordinary soda water is simply water charged as above with carbonic acid gas, but true soda water or *Vichy* water may be made by adding a little baking-soda to the water in the lower globe. *Potash* water may be got by using instead carbonate of potash, and *Selters* water by adding salt and baking-soda. In the lesson on hard and soft waters it was stated that carbonate of lime, though insoluble in ordinary water, becomes soluble in water containing carbonic acid, and this property may be utilised in preparing aërated lime or magnesia waters. In *Aërated Lime-water* precipitated calcium carbonate is added to the water, causing a milkiness, which disappears as the liquid becomes charged with gas. *Carrara* water gets its name from the similar employment of finely-powdered Carrara marble, while aërated magnesia may be made in like manner from carbonate of magnesia, and this will be found a very agreeable form of administering magnesia to children. In short, the liquid in the lower globe may be medicated to almost any extent by compounds soluble in carbonized water, thus one might have seidlitz-powders always "on draught" by dissolving Rochelle salt and other laxatives, and to patients who cannot take medicines such as iron in the ordinary forms the gazogene may prove very useful.

When added to fruit syrups, lemonade, ginger-beer, &c., may be formed, but nothing so allays thirst as natural lemon-juice diluted from the gazogene; soda and milk also will be found to lie lighter on the stomach than milk alone, especially in

cases of stomach ulcer and gastric disorders generally. When it is remembered that a dozen 5-pint charges can be got for 2*s.* 3*d.*, *i.e.* $2\frac{1}{4}$*d.* for 5 pints, and that the ordinary $\frac{1}{2}$-pint bottle costs 1*d.* or 2*d.*, it will at once be seen that a gazogene may easily save its own cost in a single hot season, while the owner may have his mind easy on the score of lead-poisoning and impure water which might, though they rarely do, affect the manufactured article. Since all gases are less soluble in heated than in cold liquids, it is not advisable to expose a gazogene to the full blaze of a summer sun, lest the increased pressure within should burst the globes.

Carbonic acid under pressure is fatal to germ life, so that aëration may really be the means of utilizing a suspicious water, especially in hot weather, when organic pollution becomes more marked, for recent researches on the subject of filtration have shown that the evil effects of impure water are due, not so much to matters dissolved in it, as to living microbes introduced by it and living upon the organic matter it contains. Besides supplying a pleasant sparkling liquid, slightly acid, and therefore cooling and refreshing, carbonic acid gas in this form has a sedative effect upon the nerves of the stomach, and either in the shape of aërated waters or of effervescing wines such as champagne and cider, is often employed in cases of sickness with stomach irritation. Vichy water is specially recommended in gastric catarrh and chronic indigestion.

Mineral Waters.—Strictly speaking, the former belong to this class, but since all waters except distilled water contain dissolved matters of some kind or other, the term *mineral water* is usually restricted to spring waters which have a peculiar taste or smell, or exercise special effects upon the body. They have been classed under the following seven divisions:—

1. *Alkaline* waters are represented on the one side by natural soda waters like those of Vichy, and on the other by those of Selters, Ems, and Salzbrun, which, in addition to carbonate of soda, contain salt, and are thus saltish in taste. These are largely prescribed for catarrh of the stomach and intestine derangement of the liver, leading to constipation and biliary disorders, and in gouty or rheumatic conditions. Still more powerful are the alkaline saline waters containing sulphate of soda (Glauber's salts), as well as the carbonate, and represented by such well-known springs as those of Carlsbad, Marienbad, and Hunyàdi János. Sulphate of soda is a fairly strong pur-

gative, and therefore these waters are given to remove dropsy, plethora, and constipation, especially the chronic constipation which arises from absence of exercise, coupled with the use of too bland a diet.

2. *Bitter* waters owe their taste and aperient action to the fact that they contain sulphate of magnesia (Epsom salts) as well as carbonate of soda. This substance is a mild purgative, less rapid in action than sulphate of soda, and has, besides, a stimulating effect upon the kidneys. In this division are placed the waters of Kissingen, Seidlitz, and Friedrichshall.

3. *Haloid* waters, or waters containing chlorides, are divisible into several classes, depending on the particular chlorides present. The hot springs of Wiesbaden and Baden-Baden, and the cold waters of Cheltenham and Homburg, contain common salt (sodium chloride) simply. Others contain in addition chloride of lithium, and this makes these more serviceable in cases of gout. When water is almost saturated with salt it becomes *brine*, used in the form of baths in Cheshire and elsewhere. Kreuznach water may be taken as a sample of water containing chlorides, bromides, and iodides; it is chiefly used for scrofula. In virtue of the common salt it contains, as well as bromides and chlorides of magnesium and others with traces of iodine, sea-water might quite well be included in this class, though perhaps its extent and cheapness put it beyond the influence of a "boom".

4. *Calcareous* waters, as the name implies, contain lime, as sulphate or carbonate, and may be regarded as extra hard waters. Like lime-water itself, these are popularly supposed to play an important part in the formation of bone, and the softness of Loch Katrine water has had to bear the blame of many a case of rickets really due to neglect of maternal duties. Since most of the lime taken into the body is expelled by the bowels as such, and since it is, moreover, apt to form insoluble salts within the body, it is very doubtful whether these waters have any advantages beyond being palatable. The waters of Bath influence the kidneys, but this may be due to their temperature.

5. *Thermal* waters, like the last-named, are chiefly used to stimulate the skin and kidneys, and excite the nervous system; they contain a small proportion of mineral matter. Among these may be mentioned the hot springs of Gastein, Clifton, and Buxton.

6. *Chalybeate* and *Ferruginous* waters contain salts of iron,

and therefore, as Sam Weller says, "taste of warm flat-irons". They are recognized by their astringent inky taste, and the rusty deposit of iron oxide which they leave on evaporating. Of carbonated chalybeate waters, containing iron carbonate dissolved in carbonic acid, the springs at Tunbridge Wells are the type. The chief use of ferruginous waters is to increase the richness of the blood, especially in cases of anæmia or debility, when the hæmoglobin of the blood is poor in iron. On entering the stomach iron compounds are converted into chlorides by the hydrochloric acid of the gastric juice, so that in a weak stomach the iron uses up the gastric acid and thus tends to hinder digestion. Even in healthy people this may occur, and so it is well to take ferruginous water or iron medicines of any kind after meals, or a few doses of hydrochloric acid, B.-P. strength, may be added to the drinking water.

7. *Sulphurous* waters are the last class of mineral waters calling for notice here, and their sulphur is in the form either of sulphuretted hydrogen gas or metallic sulphides, or both. This division includes the well-known British spas of Harrogate, Moffat, and Strathpeffer, and on the Continent, Spa, St. Moritz, Bagnères de Luchon, Aix-la-Chapelle, Aix-les-Bains, and others. Like sulphur itself, these waters are mainly used for skin diseases, and may be taken internally or as baths. They are also useful as purgatives for the lower bowel, and to relieve congestion of the liver.

Since mineral waters are recommend only for chronic disorders, it is useless to expect a disease of years to be cured in as many days,—the general course of treatment ranges from one to two months, best in summer. These waters are best taken in the morning before breakfast; the early rising is itself part of the cure, since the disorders relieved are most commonly those due to sedentary lives. Bathing is even more remedial than drinking, not only on account of the greater exercise involved, but from the greater absorptive surface. Of course it is understood that persons undergoing a "cure" are *invalids*, and must regulate their diet by that standard, and not

> "Compound for sins they are inclined to,
> By damning those they have no mind to".

SUMMARY.

1. Mineral waters contain in solution gases and solids which give them a peculiar appearance, taste, smell, or physiological effect.

2. Soda-water is water supersaturated with carbonic acid gas.

3. Mineral waters have generally an aperient action, stimulating the bowels, and, when hot, the kidneys and skin as well, while those containing sulphur act specially in disorders of the skin.

PART V.—DIETETICS.

LESSON 42.—FOOD AND DIET.

In previous lessons attention has been drawn to the various means adopted for the **preservation of food**, and it may now be advisable to have these methods summarized. They fall conveniently under four heads—

1. *Exclusion of Aërial Germs.*—This is exemplified in the preservation of eggs by closing the pores of the shell in various ways, by bottling wines or covering their free surface in the cask with olive-oil as with light wines and lime-juice. In preserving milk in this way, care must be taken to kill lactic-acid germs already present, by boiling, and bottling while hot. The large and increasing class of tinned meats are prepared in this way, being often cooked in the tin, which is then closed all but a small hole, and, on reheating so as to expel all air by steam, this opening is closed by a drop of solder. The dangers arising from the use of tinned meats are of two kinds, decay of the contents owing to imperfect closing of the tin, or more commonly incipient decay before the tin was closed, forming ptomaines; or chemical action of the juices, &c., on the solder or tin itself.

2. *Desiccation.*—This consists in removing all moisture, and is the natural method of preserving grains and dry fruits; but the process has been extended to pulpy fruits and meat, which can thus be kept indefinitely if removed from the influence of moisture.

3. *Addition of Germicides.*—The commonest illustration of this is seen in jam-making, where sugar is the germicide employed. Fruits are also preserved in syrup and spirits, while vinegar is the usual basis of pickles of all sorts. Milk preservation has been dealt with pretty fully under that head; it is most effectually preserved by a comparatively new substance—formalin. Salt is a common addition to animal foods, it tends to render meat more indigestible and must be removed before

consumption. When the salt is applied in the form of a brine, as in pickling beef, there is a considerable loss of substance, since albuminous bodies are rather soluble in salt solutions; and it has been suggested that this wasted matter should be recovered from brine by the process of dialysis, since proteids are of the class of substances called colloid. Smoking is another form of curing, applied to bacon and fish; the germicide agents in this are the carbolic and other empyreumatic vapours of a tarry order which penetrate the meat, at the same time partially drying it. Salted and smoked meats are rendered more indigestible by the process, and should rather be taken as occasional dainties than as staple foods. The making of mince for pies illustrates the preservative action of the essential oils of plants, and allusion has already been made to the antiseptic effect of cinnamon more especially in this respect. These oils played a conspicuous part in embalming, and for the same reason.

4. *Heat or Cold.*—Immense quantities of meat come from as far away as New Zealand, preserved by being frozen and kept in refrigerating chambers *en route*, and to the supplies of butcher-meat shipped in this way must now be added butter and cheese. Cold alone is not enough to kill disease germs, they must be subjected to at least the heat of boiling water, and the two processes are generally combined, heat being first applied and then cold.

Food, especially animal food, is powerfully affected by **disease of animals**, and in certain diseases the flesh is condemned unconditionally. These are—cattle plague, epizootic pneumonia, sheep-pox, acute rheumatism, acute specific diseases such as pig-typhus or scarlatina, blood-poisoning, erysipelas, black quarter, anthrax, peritonitis, and the presence of trichinæ and cysticerci. In the case of flukes in the liver (sheep rot), and cœnuri in the brains of sheep causing "staggers", these parts only need be destroyed. To these must now be added tuberculosis even in mild forms, since the recent report of the Royal Commission shows that one cannot be too cautious in using tuberculous meat, thus confirming the decision of the Glasgow inquiry. As already shown, milk from a tuberculous animal is not infected unless the disease has extended to the udders, milk being a true secretion.

Meat is to be looked upon with suspicion when infested with parasites—tape-worm is confined to the intestines and removed with the offal,—or when the animal has been suffering

from diarrhœa, affections of the heart and kidneys, foot-and-mouth disease, pleurisy, and pneumonia.

In cases where the animal has been slaughtered to anticipate death from such causes as bowel obstruction, catarrh, prolapse, and in sudden death from choking, apoplexy, or parturition, the meat may be eaten with impunity provided the blood be thoroughly drained off, while if the animal dies from an accident or through surgical operations the meat is not affected at all. "Braxy" is the name given to the flesh of sheep which have died from natural causes, and it forms the bulk of the animal food of shepherds; but even this is never eaten except after pickling or smoking, followed by thorough cooking, and treated in this way no evil consequences follow.

Diseases of vegetables are generally caused by fungi attacking them either while growing, owing to special conditions of soil and climate, or by imperfect storage. To this class belongs the smut and bunt of wheat, ergot of rye, pellagra caused by the maize fungus encouraged by damp storage, the aspergillus of damp flour, the moulds of cheese, and the fungus which attacks potatoes. Though the latter is killed by boiling, diseased potatoes should not be used as food, since though the fungus is killed its products remain, and it is these which have a toxic influence upon the consumer.

Although food be perfectly good in itself, still various disorders may arise from neglect of the rules as to the proper kind and amount.

Excess of food may not be absorbed at all, giving rise to increased putrefaction in the intestine, and causing dyspepsia, constipation, then irritation of the bowel and diarrhœa. Some of the putrefying proteid matters may get reabsorbed, setting up blood-poisoning, and this is seen in a mild form in heaviness and foul breath, fever and torpor, while jaundice even may be induced through the obstruction of bile. If the excess is absorbed the results are more varied. There is a limit to the digestion of starch and fat, and if given in too large quantities these substances appear unchanged in the fæces. Sugar is absorbed in large quantity. Excess of fats and starches delays nitrogenous metabolism and leads to the storage of fat within the body. Too much starch also causes acidity and wind in the stomach, and may even lead to the appearance of sugar in the urine. Excess of proteids produces congestion and enlargement of the liver and plethora. If exercise is not taken to correspond, oxidation is reduced and waste products are retained

within the body, leading to irritation of the excretory organs. Gout is commonly induced by alcohol and other liquids which interfere with metabolism. Great excess of proteids without any other food produces in five days febrile symptoms, malaise and diarrhœa, followed by the appearance of albumen in the urine.

Defect of food in the case of starches is well borne if fat be supplied, but if fat be withheld illness follows in a few days. Absence of fat is not well borne even if carbohydrates be given, while the absence of salts leads to marked results. If proteids are reduced the body loses strength, and its activity is lowered to meet this loss, thus throwing it open to the attacks of all specific diseases, notably malaria and typhus. If no proteids at all are given, the effects are visible only after some days, the animal drawing upon its own tissues; then the muscles lose strength, mental debility sets in with feverish and dyspeptic symptoms, afterwards anæmia and severe prostration. The excretion of urea never ceases though reduced in amount, showing that the tissues themselves are being consumed.

The evidence on both sides in the matter of **vegetarianism** may be mentioned here. Man has become by long habit a mixed feeder, but not more than $\frac{1}{4}$ of his food should be of an animal nature, since if more is given the organs excreting nitrogenous waste have their work largely increased, and the retrograde metabolism which causes gout and similar disorders may be induced. Animal food has been condemned in cancer, and Beneke's diet for that disease reduces the proportion of animal food from $\frac{1}{5}$ down to $\frac{1}{8}$ or $\frac{1}{9}$. Cancer cells contain cholesterin and lecithin, the former derived from proteids, along with alkaline and earthy phosphates; he therefore vetoes all animal and vegetable substances which contain these substances. Excess of animal food increases the amount of fibrin in blood, and the number of red corpuscles; it also increases the amount of phosphates and ash, and gives firmness and tone to muscle. The urine is rendered more acid, whereas a vegetable diet makes it alkaline; in a sucking calf the urine is acid, though the urine of herbivora is alkaline. It leads to the disappearance of superfluous fat, and upon this was founded the old treatment of corpulence. Since animal food remains longer in the stomach it allays hunger sooner than vegetable food, which is chiefly digested in the intestine; it is more stimulating, and being more easily digested, passes rapidly into the circulation, animal proteid containing only 3 per cent of indigestible matter, whereas in vegetable proteid the propor-

tion is commonly 17 per cent. The disadvantage of animal food is its absence of carbohydrates, so that it is not so well adapted for producing energy, unless a great deal of fat is present. Vegetable foods tend to increase fat within the body, as seen in the fattening of herbivorous animals, but a too exclusive vegetable diet, owing to the increase of mineral matter ingested, favours the calcareous degeneration of arteries, phosphatic gravel in the urine, and deposits of "tartar" on the teeth. With all these, it has to be said that the average Englishman consumes far too much animal food, and that he would do well to imitate the Frenchman, or even the Scot, in his more extended use of vegetables, lowering the proportion of flesh to vegetables to $\frac{1}{5}$ or so, and in so doing he would not only have a healthier body in his skin, but a clearer, harder head, and money in his pocket into the bargain.

For a **healthy diet** there are required (1) *water*, to the extent of 70 to 80 ounces daily, either as such or in foods; (2) *salts*, which form an integral part of all tissues. Alkaline salts serve to neutralize the sulphuric acid arising from oxidation of sulphur, and the withdrawal of common salt, besides other symptoms, causes albuminuria. (3) At least one *proteid*; (4) one *fat* or digestible *carbohydrate*; (5) a certain amount of sapidity or *flavour*. In order to preserve the bodily balance, so as neither to gain nor lose, the quantity of food supplied must just be sufficient and no more, must contain the several proximate principles in the proper proportion, must be digestible, and in good condition, wholesome and free from anything prejudicial to health. By repeated experiments it has been found that the proper proportion of nitrogenous to non-nitrogenous materials should be 1 to $3\frac{1}{2}$, or at most $4\frac{1}{2}$, the figures for cow's milk being 10 : 30, for human milk 10 : 37, and for wheaten flour 10 : 46. Parkes gives the following summary of daily diets for a man of average weight doing a moderate amount of work:—

	Moleschott.	Pettenkofer and Voit.	Ranke.	Average.
Proteids, ...	4·59 ozs.	4·83	3·52	4·31
Fats, ...	2·96	4·12	3·52	3·53
Carbohydrates, ...	14·26	12·40	8·46	11·71
Salts, ...	1·06	1·06	0·89	1·00
Total water-free food,	22·87 ozs.	22·41	16·39	20·55

This gives 1 of proteids to $3\frac{1}{2}$ or 4 of others, the total amount of water-free food being say 23 ozs. per 24 hours. Since food on an average contains 50 to 60 per cent of water, the total "solid" food is thus 48 to 60 ozs., added to which from 50 to 80 ozs. of water are taken as liquids, bringing up the total water to 70 or 90 ozs., or $\frac{1}{2}$ ounce per pound of body-weight. The proportions of the proximate principles is thus 1 proteid : ·6 fat : 3 carbohydrates, or as given above, 1 of nitrogenous to 3·6 of non-nitrogenous matters, or if elements be wanted instead, 1 of nitrogen to 14 or 15 of carbon. These proportions vary with season and climate, with the growth and development of the individual, and with the amount of work done. To calculate the percentage of proximate principles in any given diet, a table of dietaries is required such as is given below, and the operation is simply one of calculating percentages. To tell what quantities of given food-stuffs are required is more elaborate, demanding a knowledge of equations, but the following examples from Notter and Willoughby will demonstrate the method. Taking as the day's diet 5 ozs. proteids, 3 ozs. fat, 15 ozs. carbohydrates, and 1 oz. salts, what should be the quantities of bread, salt butter, and Dutch cheese in the daily ration? By the tables—

		Proteids.	Fats.	Carbohydrates.	Salts.
Bread (x)	contains	8	1	50	1·5
Salt butter (y)	„	—	80	—	3·0
Dutch cheese (z)	„	28	23	1	7·0

Then $\frac{8x+28z}{100}=5$ proteids.

$\frac{1x+80y+23z}{100}=3$ fat.

$\frac{50x+1z}{100}=15$ carbohydrates.

From which equations—
$x=\text{bread}=29·8$, say 30 ozs.
$y=\text{butter}=·5$ or $\frac{1}{2}$ oz.
$z=\text{cheese}=10$ ozs.

Or again, from oatmeal, milk, and bacon:—

	Proteids.	Fat.	Carbohydrates.
Oatmeal (x) =	12	6	60
Milk (y) =	4	3	5
Bacon (z) =	9	72	0

And $\frac{12x+4y+9z}{100}=5$ proteids.

$\frac{6x+3y+72z}{100}=3$ fat.

$\frac{60x+5y}{100}=15$ carbohydrates.

Whence—
$x=\text{oatmeal}=19·2$ ozs.
$y=\text{milk}=69·6$ ozs. $=3\frac{1}{2}$ pints.
$z=\text{bacon}=4·8$ ozs.

The salts may be calculated as above, or by a percentage of the articles used.

SUMMARY.

1. Food is preserved by the following processes:—Exclusion of air, desiccation, addition of germicides, heat, and cold.

2. Animal flesh is condemned for human food by reason of disease, but not when the animal has died accidentally.

3. Both excess and defect of proximate principles lead to bodily disorder, the proper proportion for health being 1 proteid : ·6 fat : 3 carbohydrates, *i.e.* 1 of nitrogenous to 3·6 of non-nitrogenous, or 1 of nitrogen to 14 or 15 of carbon.

4. The precise nature of a dietary depends upon several factors, season and climate, age, sex, and condition, as well as output of work.

DIETARY TABLE.

	Water.	Prot.	Fat.	C'Hyd.	Salts.
Animal Flesh—					
Beef, lean, ...	74·4	20·5	3·5	—	1·6
Ordinary beef and mutton, bone $\frac{1}{5}$,	75	15	8·4	—	1·6
Fat meat, ...	63	14	19	—	3·7
Mutton, average, ...	76	18	5	—	1
Roast meat, no loss, ...	54	27·6	15·45	—	2·95
Corned beef, ...	52·2	23·3	14	—	4
Salt beef, ...	49·1	29·6	·2	—	21·1
Salt pork, ...	44·1	26·1	7	—	22·8
Fat pork, ...	39	9·8	48·9	—	2·3
Dried bacon, ...	15	8·8	73·3	—	2·9
Smoked ham, ...	27·8	24	36·5	—	10·1
Horse flesh, ...	74·3	21·7	2·6	—	1
Veal, lean, ...	78	19	1·5	—	1·5
Fish and Poultry—					
White fish, ...	78	18·1	2·9	—	1
Herring, fresh, ...	80	10	8	—	2
Sole, ...	86	12	·5	—	1·5
Salmon, ...	76	15	7	—	2
Eels, ...	57·5	12·5	28·5	—	1·5
Poultry, ...	74	21	3·8	—	1·2
Goose, ...	38	16	45·5	—	·5

	Water.	Prot.	Fat.	C'Hyd.	Salts.
DAIRY PRODUCE—					
Milk, cow's, average, ...	86·9	4·7	3·5	4·2	·7
" average, town, ...	86	5	4	4·3	·7
" Devonshire, ...	90·35	4·2	1·15	3·5	·7
" condensed, English, ...	27	12	8·4	50·8	2
" " Swiss, sweetened,	25·6	12·3	11	48·7	2·4
" " " unsweetened,	61·85	11·35	11·25	12·35	2
Skimmed milk, ...	88	4	1·8	5·4	·8
Cream, ...	66	2·7	26·7	2·8	1·8
Butter, ...	7·5	13·5	11·6	—	1
" English, fresh, ...	12	2	85	—	1
" very best, ...	8	1	90	—	1
" salt, ...	17	—	80	—	3
" very salt, ...	17	1·0	74	—	8
Margarine, ...	12·03	·75	82	—	5·22
Cheese, single Glo'ster, ...	36	31	28·5	—	4·5
" Dutch, ...	41	28	23	1	7
" poor, ...	48	32	9	7	4
Eggs, $\frac{1}{10}$ for shell, ...	78·5	12·5	11·6	—	1
FARINACEOUS FOODS—					
Bread, average wheaten, ...	40	8	1·5	49·2	1·3
Wheaten flour, ...	15	11	2	71·2	·8
Barley-meal, ...	11·3	12·7	2	71	3
Pearl-barley, ...	14·7	7·3	1·1	75·8	1
Rye, ...	13·5	13·1	2	69·3	2·1
Biscuit, ...	8	15·6	1·3	73·4	1·7
Rice, ...	10	5	·8	83·2	·5
Oatmeal, ...	15	12·6	5·6	63	3
Maize, no cellulose, ...	13·5	10	6·7	64·5	1·4
Macaroni, ...	13·1	9	·3	76·8	·8
Millet, no cellulose, ...	12·3	11·3	3·6	67·3	2·3
Arrowroot, ...	15·4	·8	—	83·3	·27
Peas, dry, ...	15	22	2	53	2·4
Lentils, ...	12·5	24·8	1·8	58·4	2·5
VEGETABLES—					
Potatoes, ...	74	2	·16	21	1
Carrots, no cellulose, ...	85	1·6	·25	8·4	1
Parsnips, ...	82·5	1·3	·7	14·5	1
Turnips, ...	91	1	·2	6·8	1
Cabbage, ...	91	1·8	·5	5·8	·7
Brussels sprouts, ...	85·5	5	·5	7·8	1·2
Beet-root, ...	87	1·5	—	10·5	1
Pemmican, ...	7·2	35·4	55·2	—	1·8

LESSON 43.—DIET AND AGE.

Besides season and climate, which greatly influence diet, the most important factors in this respect are the age and condition of the individual, and for this purpose life may be divided into three stages, 1st, the period of growth and development, including infancy and childhood up to 10 years of age, and adolescence up to 18; 2nd, adult life, when both growth and development have been completed; 3rd, decline, as in advancing age.

Infants are brought up either on natural human milk, supplied by the mother or a wet-nurse, or on artificial substitutes, generally cow's milk. In the first case, since a child has no power of digesting starch till the teeth begin to come, it should be confined to mother's milk for the first 8 or 9 months of its life, and for the first year and a half milk will be the staple food. The first milk, or colostrum, is a natural purgative, and the regular supply of milk does not start till after a day or two; the casein and fat in the milk increase up to the end of the 2nd month, salts up to the 5th, and sugar till the 8th or 10th month. The amount of casein and sugar present is always proportional to the quantity of milk, that of fat inversely so, and the milk supplied to a first-born child is always richest in solids. An infant's stomach is a very small affair, containing after 5 days only $6\frac{1}{4}$ fl. drachms, but its capacity increases rapidly at first, at the end of the 4th week being $1\frac{1}{2}$ or 2 times as much, and after the 8th week $3\frac{1}{5}$ times. From this point, however, increase in bulk is comparatively slow, the capacity after 20 weeks being only $3\frac{4}{5}$ times what it was at 5 days; care should therefore be taken to give only small amounts at short intervals, say every 2 hours for the first fortnight, then every 3 hours till the end of the 2nd month, and from that till the 7th month every 3 or 4 hours, during the daytime. When the teeth are coming in the 7th and 8th months saliva begins to flow, and some self-digested starchy matters may be given once or twice a day along with milk; but the child is still a carnivorous animal, and, along with milk, mutton broth or mutton jelly may be given, or eggs in custard. Children are generally weaned about the 10th to 12th months, but the precise time for this depends on the state of health both of mother and child. When the child is $1\frac{1}{2}$ years old the diet may be varied

by the gradual introduction of white flesh, stale-bread crumbs, biscuit, mutton, and beef, and when the molar teeth are well formed, foods demanding some chewing.

Diet in Nursing.—If a wet-nurse is employed, the infant should be about the same age as her own to secure the proper composition of milk; after 3 months the milk is fairly uniform in quality. A woman who has had several children is preferred, but simply on the ground of experience in nursing. Both for wet-nurses and nursing mothers diet is a matter of supreme importance, generally erring on the side of richness. Instead of being dosed with butcher-meat and porter, and cooped up in the nursery, nurses should avoid beer and all rich foods, and confine themselves to a diet, simple, regular, and nutritious, and should take as much exercise as possible. To overcome constipation arising from too much confinement oatmeal may be taken, while the flow of milk is increased by milk-gruel, broth, or chocolate. As already mentioned, drugs taken by the mother often pass into the milk.

Artificial Feeding.—When an infant has to be brought up on the bottle, care must be taken to dilute the cow's milk generally used, so as to make it resemble human milk as much as possible. The difference in character of the casein obtained from cow's and human milk by curdling with rennet or gastric juice has already been referred to, and it is useful to know that the proteids in cow's milk curdled by acids are four times as much as the other proteids, whereas in human milk the proportions are reversed, non-coagulable proteids being double the amount of those curdled by acid. Children have their livers large as compared with adults, and proteids and fats bulk more largely in their diet, the proportion of carbohydrates and fats being almost equal, whereas in the adult they are 3 to 1. When condensed milk is used it is generally diluted so much as to give too little casein and fat, while to increase the quantity means excess of sugar, and more than half of that is in the form of cane-sugar, which tends to produce irritation by fermentation. To supply the deficiencies of fat and casein a little cream and white of egg may be added. The one advantage of condensed milk is its convenience in travelling, or in out-of-the-way places where milk is scarce, or as a last resort in an emergency. Says Dr. Louis Starr, "Infants fed upon condensed milk, though fat, are pale, lethargic, and flabby; although large, are far from strong; have little power to resist disease; cut their teeth late; and

are very likely to drift into rickets before the end of the first year".

Farinaceous foods are best withheld till about the 8th month, and even then should be self-digestive, consisting of malted starch and dextrin, and should be used along with milk. The delusive nature of arrowroot is shown by the fact that its proteids are only $\frac{1}{20}$ of its carbohydrates, and those last are pure starch, indigestible by an infant, while in human milk the proportion is $\frac{1}{5}$, and the carbohydrate is in the form of milk-sugar. Dr. Starr has drawn up elaborate directions for infant-feeding, but the personal equation bulks very largely, and it is a safe rule to be guided by the thriving of the child itself.

Adolescence is the period characterized by growth of all the organs, especially the muscles, and it is the period devoted to mental training in schools. To meet these bodily demands the diet must be such as to admit of rapid digestion and assimilation, while liberal enough to be of all-round utility. Children of school age detest fats, and the necessary heating matters may be given as butter or as suet in puddings, while treacle, syrup, and the multitudinous jams supply a copious store of carbohydrates.

Adult life, marked by complete bodily development, occurs at or before 25, though in females it may be 8 years earlier. The body, however, continues to increase in weight unless proper exercise is taken, and when this is coupled with over-feeding, which is generally the case, biliousness sets in, and at a later stage corpulence, indicating the storage of unused material, while a foundation is laid for disease of retrograde metabolism such as liver disorders, gout, and rheumatism. The cure for these tendencies is plainer living coupled with more exercise, while the diet may be modified so as to present light foods with a small amount of butcher-meat, and fruit or vegetables to keep the blood in proper condition and prevent constipation.

In *Food and Feeding* Sir Henry Thompson classes the various **systems of meals** under three divisions: 1st. The *Continental* system of two meals a day, dejeuner à la fourchette from 11 to 1, followed by dinner, 6 to 7, after the day's work is over. The only thing taken as breakfast is a roll and butter with café au lait or chocolate, and as the professional classes begin work much earlier than with us, the dejeuner or lunch comes in after about 3 or $3\frac{1}{2}$ hours' work. The quantity of food

taken is less than in England, but more attention is paid to cookery. 2nd. The middle-class English or *Provincial* system, best suited for children and young growing people with good digestions, has four meals a day—breakfast at 8 a.m.; dinner at 1, in Germany at 12.30; a heavy tea, the great defect in the system, 5 to 6; and supper about 8 or 9, in Germany 7.30 or 8; while there should be an interval of 2 or 3 hours between supper and bed. 3rd. The *London* or professional system comprises breakfast, lunch, and dinner, the last, as in France, after the day's work. As a refreshment in the long interval between lunch and dinner, tea comes in at 5 o'clock, best taken simply as a refreshment. With dinner after 6 o'clock, or for suburban residents after 7, lunch at 1 requires to be ample for supporting the bodily powers, and yet not heavy, otherwise the afternoon's work will suffer, or may react upon digestion, laying up an account for dyspepsia.

The **period of decline** is characterized by several organic changes; the muscles lose their tone, and this occurs not simply in the voluntary muscles but in the coats of the intestines, so that the latter are more subject to dilation, flatulence, and constipation. This want of tone affects also the blood-vessels and the circulation generally, varicose veins are common, and absorption is delayed because of retarded circulation; while the digestive system becomes weaker, and the mental powers share in the decreasing debility. The disappearance of the teeth indicates a change in the character of the food taken, and in this way the dentist's aid may not be an unmixed blessing, since the stomach can no longer endure the strong foods of former days. For healthy age the body should resemble that of a healthy schoolboy, lean and spare, with just so much fat as keep out the cold, and the diet should also approximate to the same standard, fats and rich foods being reduced in quantity, animal foods strictly cut down to their proper proportion, $\frac{1}{4}$ or less, and the meals small and often. If the decline of energy is not thus accompanied by a corresponding diminution of the demands upon it in the form of digestive activity, the result is certain to be accumulation of fat and retarded or even retrograde metabolism, producing gout and rheumatism. In advancing age the diet more and more approaches that of youth, and in second childhood a return is made to the bread-and-milk diet and short intervals of early days.

SUMMARY.

1. Diet should be regulated to keep pace with physiological changes.

2. An infant is carnivorous, and should not receive starchy foods till the 7th or 8th month, any solid food before that being predigested by extract of malt, or consisting of dextrin and sugary matters.

3. Children need a liberal diet, four meals a day with short intervals between, and no "pieces" in these intervals.

4. The evil of adult feeding is excess, coupled with insufficient muscular exercise, leading to sedentary troubles and metabolic irregularities.

5. In declining years food should be diminished to correspond both in quality and quantity with the declining energies.

Lesson 44.—FOOD IN SICKNESS.

Science has been described as "organized common-sense", and this description is specially true of modern medicine, based as it is upon the sciences of physiology and chemistry, including under the latter, diet and the action of drugs. Although in a single lesson it is impossible even to sketch the proper diet for each disorder, still it may be worth while to indicate at least some of the principles which should guide a nurse or a patient, leaving it to systematic works on medicine to supply the details. To illustrate the dietetic treatment of diseases, we may take the class of **Fevers**. In all these assimilation is greatly interfered with, and in acute cases scarcely any food at all is absorbed by the stomach, so that nearly all digestion is intestinal, and even that is enfeebled. In a fever, moreover, two things must be kept in view—(1) to check waste of tissue, and (2) to keep up nutrition, and without having recourse to the extreme methods of Drumtochty, which demand a constitution to match, it is easy to lay down general rules for guidance in matters of diet. Since the digestive processes, especially in the stomach, are much impaired, it is quite out of the question to give "strong" foods, such as beef-tea or eggs, in the mistaken search for strength, for every invalid must return for purposes of diet to the condition of a child, and in severe cases to that of an infant even. Fever patients are generally overfed, and even milk, bland as it is, will be

found too strong in acute cases, just as it is for an infant. Sir William Jenner points out in this connection that a pint of milk contains as much solid matter as a full-sized mutton-chop! Milk, therefore, must be diluted as for a young child, either with a natural alkaline water, such as Apollinaris or Vichy, or the latter may be imitated by adding to a cupful of milk and water 3 grains each of baking-soda, common salt, and bicarbonate of potash, and 2 grains of magnesia. The addition of a few drops of brandy will not only supply a useful stimulant, but will help to predigest the milk, the object in all cases being to give a food very easily absorbed and assimilated. Some people cannot tolerate even milk, and they should try skim-milk or butter-milk. As convalescence progresses, milk may be supplemented by light beef-tea or clear soup free from fat; the oatmeal jelly already described will be found excellent, even in cases where milk and water proves irritating, nutriment in such a case being given in small quantities and at short intervals. Thereafter, in ascending order of difficulty, doctors allow peptonized meats, animal jellies, arrowroot and other farinaceous foods in milk, tea, and the like in small quantities and occasionally, then short-fibred white flesh-meats, such as chicken and fish. Acid fruit-juices, such as home-made lemonade, are best for allaying the thirst which characterizes all fevers, and these beverages may be made more nourishing by adding albuminous materials, as in albumen water, made from white of egg whipped in two parts of water and strained, or Semmola's glycerine drink, 1 oz. of glycerine and 3 ozs. of citric acid to a pint of water, this latter being specially useful for dry throat.

Certain specific infective diseases have one or two points of peculiar interest. Thus in *Diphtheria*, owing to the action of the virus on the nerve-centres, food must be at once nourishing and stimulating, and good sound port wine bears a good name in these respects. In *Whooping-cough*, again, owing to the spasms, which interfere with the regular action of the stomach, the food must not only be fluid, but rapidly digestible, *i.e.* it must be peptonized beforehand. To keep down the vomiting induced by the spasms, black coffee may be given, and immediately after vomiting, peptonized milk with a few drops of brandy, thus surprising the stomach, as it were, into retaining food, while feeding by the bowel is useful as a complementary proceeding.

In *Typhoid Fever* abundance of liquids should be given,

because in this disorder the blood is deficient in water; and, since the small intestine is more especially the seat of attack, the food should be such as can be digested and absorbed in the stomach, *i.e.* farinaceous and fatty foods should be reduced to a minimum, the diet consisting of animal albuminates, salts, extractives, and other stimulants.

In **Rectal Feeding** it has to be remembered that although the large intestine absorbs readily enough suitable fluid materials, such as water with dissolved salts and peptonized foods, still it has no direct *digestive* action, and it is entirely powerless to digest say an enema of beef-tea or milk, except the salts contained in these, while enemata not nearly so nutritive, consisting of wine and alcohol, are readily absorbed. Since the large intestine is irritated by acids, all nutrient injections should be alkalinized by adding baking-soda. The following is highly recommended for rectal feeding:—Egg yolk beaten up with a glass of milk, and peptonized by adding 2 dessert-spoonfuls of solid peptone or 2 table-spoonfuls of liquid peptone with 7 or 8 grains of baking-soda, and 5 drops of laudanum to soothe the highly-irritated bowel. Ewald found that richness in peptone is no criterion of absorbability, and, as a matter of fact, eggs, which are poor in peptone, are more readily absorbed than other foods containing 2 to 5 times the amount of peptone. Instead of using peptone the eggs may be prepared at half the cost and with increased efficiency by adding pepsin and hydrochloric acid, as in gastric digestion, or the liquor pancreaticus to imitate intestinal digestion. Absorption is further facilitated by the addition of 15 grs. of common salt to each egg. To prevent rejection by the bowel the latter should be washed out by an enema of tepid water, after which the food, warmed to about blood-heat, should be introduced very slowly, best not from a syringe at all, but delivered from a funnel by an india-rubber tube solely by the action of gravity. With due care the food may even succeed in passing the ileo-colic valve and reaching the small intestine, where digestive activity is great.

Disorders of the Stomach itself, such as gastric catarrh, ulcer, or cancer, call for *rest* to that organ; therefore all foods must be non-irritating, and given at as long intervals as is consistent with nourishment. Milk diluted with an equal bulk of iced alkaline water, with the occasional addition of watery arrowroot, will be found at once bland and nourishing; but for chronic cases, and indeed dyspepsia generally, butter-milk

will be found immensely superior, and better tolerated. Fats should be strictly forbidden, as they tend to form fatty acids in the stomach and prevent the gastric juice from getting at the food, while carbohydrates should be avoided, owing to their tendency to undergo acid fermentation, often causing dilatation. To ensure thorough admixture with gastric juice, the meat should be well chewed, or served as mince and purées, short-fibred meats being preferred.

When **Dilatation** of the stomach by accumulation of gases becomes a distressing symptom, the principle of *resting* the organ must be carried out to the last degree; hence all food supplied should be easily digested and absorbed, even predigested, and should consist chiefly of animal food, finely divided, to admit of rapid action. The intervals between meals in such cases will lengthen out to eight or nine hours, so that the food supplied must be fairly concentrated. As above, carbohydrates should be cut down to a minimum, flatulent vegetables like cabbage being especially shunned. Suitable animal diet will be afforded by chicken, white-fish and game, and eggs lightly boiled, besides milk as before, and in all cases a drink of warm alkaline water will not only wash away a great deal of the ropy mucus which clogs the gastric glands, but will encourage the glands themselves to increased secretion. The following is given as a model diet for dilatation:—

7.30 A.M. Small tea-cupful of hot water.

8 ,, Breakfast: 2 poached eggs, or small grilled sole with lemon-juice; 1 oz. thin toast; 2 to 4 ozs. beverage, water or hot milk and water.

1.30 P.M. Small tea-cupful of hot water.

2 ,, Luncheon: 4 ozs. boiled rice, tapioca, or sago, with a little fruit jelly, or macaroni with a little grated cheese. Milk may be used in preparing these. 4 ozs. of water, or weak brandy and water.

7.30 ,, Hot water as before.

8 ,, Dinner: Loin of mutton chop, or slice of the lean of roast or boiled mutton or chicken; or not more than 3 ozs. of roast beef; 1 oz. purée of potatoes; 1 oz. dry toast; 4 ozs. of water as above.

11 ,, ½ tumblerful of Vichy water.

A cup of milk and Vichy water or cold beef-tea during the night, if necessary.

Ulcer of the stomach demands more careful handling, but still on the principle of rest. The points to be aimed at are these:—(1) to avoid irritation, either mechanical or chemical; (2) to avoid foods which would increase the acidity of the stomach, since the acid secretion injures the surface of the ulcer; (3) to avoid foods which tend to ferment and produce dilation, with possible stretching of the sore. The patient is thus shut up to bland fluid food, given in small quantities, not more than 2 ozs. at a time, and a beginning may be made with milk diluted with its own bulk of boiling water or soda water. Later on, an egg beaten up with 2 table-spoonfuls of water and strained ("albumen water"), may be added to 2 ozs. of the diluted milk. Oatmeal jelly may be used here, and is readily assimilated; but it must be a real jelly, containing no irritating granules.

Cancer of the stomach is treated in the same way, but if the cancerous growth be at the pyloric end one must aim at having all food digested, as far as possible, in the stomach itself, so as to obviate the passage of irritating materials through the diseased part. Owing to their tendency to ferment, carbohydrates must be abandoned, and the dietary will take the shape of milk and alkaline water, peptonized milk, beaten eggs, or concentrated meat solutions, predigested, if need be, to spare the stomach work, an end also attained by rectal feeding.

Although the general causes of **Dyspepsia** have already been dealt with, it may be useful here to recapitulate the most useful diets. Its most frequent cause is the introduction into the stomach of crude undigested masses, and so treatment here begins with the teeth. Food must be properly chewed and slowly eaten, and when the teeth are prematurely deficient their place should be supplied or the food given in a finely-divided form. Meats, therefore, should be of the short-fibred white description, bread rather stale, vegetables in purées, and fats finely minced. All irritating matters, such as the cellulose of unripe fruits, vegetables, and nuts, should be shunned, while sweetened dishes are best left alone, on account of acid fermentation. Fats are best finely divided; even butter should not be used as in toast buttered warm, since the bread gets saturated with butter, and is so far protected from the action of the gastric juice. Since in dyspeptics the stomach functions are enfeebled, the times of digestion given on a previous page would require to be almost doubled, allowing an interval of from 5 to 8 hours or even more between meals, "one of the

facts of feeble digestion most difficult to get accepted, not only by the patient, but often also by the doctor" (Yeo, *Manual of Med.* i. 152). Tea and coffee interfere with gastric digestion, and, if taken at all, are best taken 3 or 4 hours after a meal; but a glass of hot water will be found just as stimulating, without any danger. Prof. Schulzenstein found that 94 per cent of coagulated white of egg was digested in 8 hours by an artificial gastric juice; of albumen and tea only 60 per cent, with coffee 61 per cent. In all cases of dyspepsia the guiding principles are to supply sufficient nutriment, but with that to give the enfeebled organ as little to do as possible, taking care, therefore, that the food supplied shall be strictly regulated by the digestive capacity of the stomach for the time being.

As already explained, **Constipation** is due to deficiency of fluid in the intestine, and this may be rectified by increased use of liquids; thus a tumbler of cold water may be taken on rising and another before going to bed, with one of hot water half an hour before dinner. At the same time the intestinal glands may be stimulated to more vigorous action by a liberal use of oats, vegetables, and fruits, which contain much cellulose, and generally, the proportion of vegetable to animal food should be much increased. Intestinal activity is further promoted by using plenty of fresh butter, thus inducing a greater flow of bile. Honey, treacle, and gingerbread will be found useful aperients, while the free use of grapes, 4 to 6 lbs. daily, is alone sufficient to restore the normal state of matters.

Anæmia or bloodlessness is often caused simply by deficiency in animal food, and may be remedied by increasing the proportion of the latter, especially in the form of yolk of egg, for the iron contained in it, milk and cream to supply fat, and meat as nearly raw as the patient can bear. Since the digestive powers share in the general weakness, food should be given in small quantities at a time.

Among disorders of assimilation **Liver Complaints** demand attention. In all these the diet should be of the plainest possible description, and strictly limited in quantity, fats and carbohydrates being avoided, since it is with the digestion of these that the liver is chiefly concerned. Bread should be taken but sparingly, and as dry toast, and animal food in great moderation, but fruits and vegetables, cooked or in salads, may be drawn upon to supply the necessary nutriment. In cases of gall-stone eggs should be eschewed, since the yolk contains cholesterin, a constituent of gall-stones, and for a similar reason

carrots are best left alone; on the other hand, olive-oil has a remarkable influence in checking such formations. In catarrhal jaundice the diet resembles that for fevers, at first warm milk and water, alkalinized as before, then peptonized gruel, peptonized cocoa and milk, or thin arrowroot, milk soups flavoured with Spanish onion or celery, and beef-tea thickened with sago or tapioca. At all meals warm alkaline drinks should be taken.

Acute Rheumatism, or Rheumatic Fever, is a constitutional disease characterized by excess of lactic acid in the blood, and while the pain in the joints calls for external appliances, the acid state of the blood indicates the use of an alkaline diet, while the great loss of water by perspiration demands a liberal allowance of liquids. The diet should thus be very fluid, easily absorbed and cooling, so as to reduce fever. Milk diluted with its own bulk of boiling water, alkalinized by the addition of 30 to 40 grs. of baking-soda and 10 to 20 grs. of common salt to the jug, then cooled by ice, will supply nutriment enough, and in this way 3 or 4 pints of milk may be taken in the 24 hours. If milk disagrees, whey may be used, and in any case a jug of home-made lemonade should be standing near, to be taken by the patient between his draught of milk. When the fever is subsiding the milk may be supplemented by barley-water, oatmeal jelly, or well-strained gruel, followed, as convalescence proceeds, by light clear soups, thickened by stale-bread crumbs and farinaceous matters, then chicken and beef pounded and minced rather than as strong extracts, also bread and milk and other light farinaceous puddings. Alcohol must be entirely avoided, both in the acute and chronic disorders; the best drink is home-made lemonade, with the addition of 20 to 30 grs. of bicarbonate of potash to the jug. In **Chronic Rheumatism** the dietary has a wider range, but must be light and easily digested, the object being to promote normal metabolism, and the state of the urine as to deposits will afford a good indication of this. Animal food is restricted with advantage as tending to render the blood acid, but it may include white fish, game, poultry, and tender meat. Vegetables may be freely used—especially stewed celery and Spanish onion, which are almost popular specifics for rheumatism—lettuces, water-cresses, and fruits, along with farinaceous foods, while the necessary fat is obtainable from milk, cream, and butter. As in rheumatic fever, the best beverage is lemon-juice, which may be pleasantly combined with soda or potash water, or the orange, lemon, &c., may be eaten fresh.

Gout is a disorder of elimination, in which the natural breaking up of nitrogenous matters is interfered with, and the waste products thus formed accumulate within the system. The dietary treatment clearly aims at promoting the removal of the waste already formed and preventing any fresh accumulation. All substances, therefore, which in any way check or interfere with the regular metabolism of nitrogenous matters should be dropped, and this disposes of alcohol, as well as fats, sugar, and starches, since all these are easily oxidized within the body, and are to that extent "albumen-sparing". This leaves animal foods of a simple kind, but excluding yolk of egg, unsuitable on account of the lecithin in it; and in most cases a patient will do best on milk or whey and hot water, thin oatmeal gruel, and thin veal or chicken broth, with occasionally weak tea and dry toast. With convalescence this simple diet may be gradually supplemented by adding once a day boiled mutton, or chicken and rice, or grilled sole or whiting, with sliced lemon, or an egg poached or boiled may be added at breakfast to the dry toast. Meals should be as much as possible homogeneous, *i.e.* carbohydrates should be taken by themselves at one meal, flesh at another; and the liberal use of *hot water* will promote elimination of gouty products, removing these both by the kidneys and the skin.

Enough has already been said about **Diabetes** to indicate that this may be due to a disordered liver or to deranged assimilation. In the former variety a cure may be effected by strict diet, excluding all substances convertible into sugar, *i.e.* all carbohydrates whatsoever. In the more severe form, accompanied by emaciation, sugar is formed at the expense of the tissues themselves, and diet alone is powerless to arrest this, a very serious disease. The standard diabetic food is milk, and the exclusive use of skim-milk has been able to remove all sugar from the urine in a fortnight. The principles upon which this disease is to be treated are thus laid down in works on medicine:—

1. Reduce to a minimum or avoid altogether all substances containing starch or sugar.

2. Give as much animal food as can be comfortably digested and assimilated.

3. Replace the discarded carbohydrates by suitable substances from among the animal and vegetable fats and oils.

4. Except in the severe form, encourage muscular exercise to consume the excess of sugar in the blood.

Urinary disorders, like gout, are generally betrayed by imperfect nitrogenous metabolism, since nearly all the nitrogenous waste of the body is removed by the kidneys in the form of urea. A common retrograde change is the increase of uric acid at the expense of urea, and since this tends to form salts insoluble in acid urine, the blood ought to be kept alkaline. This necessitates cutting down the proportion of animal food, with a corresponding increase in that of vegetables, assisted by alkaline drinks to diminish acidity. In *Oxaluria*, or poor man's gravel, on the other hand, the urinary deposits are not urates but oxalates, generally induced by excess of vegetable foods, especially those rich in oxalic acid, such as rhubarb, sorrel, tomatoes, cabbages, haricots, celery, with black tea. These should be left alone, and a good but light animal dietary substituted, while to promote alkalinity the stomach may be washed out every morning by a drink consisting of 2 to 3 ozs. of Carlsbad salts in $\frac{3}{4}$ pint of hot water, and before retiring for the night, by a tumbler of alkaline water, not lime-water, since oxalate of lime is insoluble in water, but Vichy, Apollinaris, or the artificial Vichy already mentioned. For *Bright's Disease*, where the structure of the kidney is affected, milk is ordered, because it is rich in albumen and fat, but in forms rapidly absorbed and therefore yielding a minimum of waste, besides being non-irritating and an active diuretic in virtue of the lactose it contains. It may be taken in small mouthfuls at a time to secure complete digestion, while the kidneys may be well washed by the free use of alkaline fluids or home-made unsugared lemonade, the citric acid of which becomes alkaline carbonates. A pleasant and nutritive beverage is the so-called "imperial drink", made by adding 1 dram of cream of tartar and the juice of half a lemon to a pint of hot water and allowing it to cool. Chronic forms of Bright's disease call for a purely milk diet, preferably as skim-milk, and if diluted with one-third of hot water and salted in the proportion of 20 grains to the pint, this food will be found more digestible. Hot-milk soups may be given, flavoured, as for rheumatism, with celery or Spanish onion, or thickened with isinglass and flavoured with lemons; and if the patient tires of milk he may get toast, farinaceous foods, or vegetables in moderation.

Nervous disorders are often due to deficient nourishment, letting the system "down" too far. Thus neuralgia demands a liberal diet with plenty of fat; paralysis, a full nutrition by

all the proximate principles, especially fats, up to the limits of digestion, with plenty of water to encourage elimination by the kidneys and skin; while tubercular meningitis needs milk, iced to reduce the fever. Apoplexy, again, is generally due to excess of food both in quantity and richness, and persons of this tendency should exercise great temperance both in eating and drinking, avoiding butcher-meats, fats, and sugary foods, and deriving their nutriment chiefly from white meats, with green vegetables and fruits for the sake of their laxative action. The treatment of **Hysteria** and neurasthenia, derangements characterized by exhaustion, feebleness, and irritability, is based upon the principle of rest, any exercise being of the passive sort, as massage. J. K. Mitchell gives the following daily programme in cases of this kind:—

7 A.M.	Cocoa. Cool sponge-bath with rough rub and toilet for the day.
8 „	Breakfast with milk. Rest an hour after.
10 „	8 ozs. peptonized milk.
11 „	Massage.
12 noon	8 ozs. milk or soup. Reading aloud by nurse half an hour.
1.30 P.M.	Dinner. Rest an hour.
3.30 „	8 ozs. peptonized milk.
4 „	Electricity.
6.30 „	Supper with milk. Rest an hour.
8 „	Reading aloud by nurse half an hour.
9 „	Light rubbing by nurse with drip-sheets.
	3 ozs. of malt extract with meals, and a tonic afterwards. 8 ozs. peptonized milk with biscuit at bed-time, and a glass of milk during the night if desired.
	Laxative (cascara) 10 to 30 drops occasionally.

At a later stage Swedish movements to be added after the massage.

The only other disorder to be discussed here is *Phthisis* or **Consumption**, our national scourge. In this disease the appetite is most capricious and is easily lost, so that it must be tempted by good cooking, and by appetizing dishes well served and agreeably varied, while keeping the materials fluid and easily absorbed. Farinaceous foods are well suited for this trouble, especially oats and maize, which spare the tissues strongly

owing to their richness in fat. If cod-liver oil can be taken, it is of great advantage in poor and ill-fed patients, who may take two tea-spoonfuls twice a day; but in febrile phthisis the pure oil is not well tolerated and is best given in emulsions. Glycerine, 10 to 15 drams daily, is an admirable substitute for the oil, since it not only promotes assimilation, but lessens waste, the urea being diminished though the carbonic acid is increased, so that there is an increase in body-weight. Cream, often used instead of cod-liver oil, is better diluted with its own bulk of hot water, with the addition of a tea-spoonful of brandy or aromatic spirit of ammonia to each tea-cupful. Milk should be taken freely, 2 to 3 glasses between meals, and a glass the last thing at night. As in other cases, milk will not pall so readily when mixed with soda or selters water. Koumiss has quite a reputation for the cure of pulmonary tubercle, but the climate of the Caspian stations has a good deal to do with the success of this treatment. Digestion is often interfered with by vomiting coming on after food has been taken, and in this case a tumbler of hot milk and selters, or a tea-cup of hot beef-tea or chicken-broth should be taken before the meal, as little fluid as possible during it, and a little pepsin and hydrochloric acid after the meal to assist gastric digestion. The following diet for consumption is given by Yeo (*Medical Treatment*, ii. 100):—

On waking.	Tumbler of milk with hot water, with salt and baking-soda to get rid of accumulated mucus.
9—10 A.M.	Breakfast. Boiled bacon and light-boiled eggs; or fish; or cold meat; with tea, coffee, or cocoa.
12 noon.	Glass of milk or cup of beef-tea.
1.30 or 2 P.M.	Dinner. Fish, meat, chicken, or game. Fresh vegetables. Light milk-pudding, with marmalade or cooked fruits.
5 ,,	Another glass of milk, or thin chocolate, or tea with plenty of milk, or egg yolk switched.
6 ,,	Similar to dinner.
	Half an hour before bed-time more milk, arrowroot, beef-tea, or tapioca soup.

For specific instructions in each disease, and for the whole

subject of sick dietaries, the student is advised to consult the standard works on the practice of medicine, and more especially Burney Yeo's invaluable work, *Food in Health and Disease.*

SUMMARY.

1. In most disorders dietetic treatment proceeds upon the principle of rest, especially when the digestive organs themselves are involved.

2. Foods must therefore be easily absorbed and assimilated, yet sufficiently nutritious to maintain strength.

3. The standard food in most diseases is milk, diluted with hot water and alkalinized.

4. Generally speaking, a patient approaches a child in proportion to the severity of an attack, and requires to imitate the child's or even the infant's diet both as to quality and quantity.

5. When the stomach is directly involved it has to be humoured and even surprised into digestion, the methods depending on the disease.

6. Metabolic disorders, like gout, call for increased elimination of waste and a diet calculated to give a minimum of waste.

7. In all abnormal conditions the "personal equation" bulks largely, and individual idiosyncracies must be carefully considered.

Lesson 45.—METHODS OF COOKING.

Man has been defined, by a Frenchman doubtless, as the cooking animal, and, with the exception of a few savage tribes, all races of men find it necessary to prepare their food by some process. Since the functions of digestion and assimilation are best carried on at blood-heat, one object of cooking food is to spare the bodily energies as much as possible by raising the food to that temperature; and again, in another direction, by softening hard tissues, or by hardening tough tissues, rendering them brittle, and so prepared for mastication. While these *mechanical* changes are brought about, cooking produces *chemical* changes also; thus, starch gets dextrinized or even changed into maltose, connective tissue becomes gelatin, and there are developed from the proteids of meat osmazone and other odorous substances which impart flavour and stimulate the appetite. Lastly, cooking plays a most

important part in the destruction of parasites and germs of disease.

The different methods of cooking employed are boiling, steaming, stewing, and soup-making, effected by water; roasting, broiling, and baking, by radiant heat; frying, by hot oil or fat; but these are all reducible to two divisions, depending on whether the object in view is the extraction or retention of the juices of the food-stuff in question.

Classed in this way, the several methods will appear thus—

Roasting, Grilling, Baking, by radiant heat and hot gases.		
Steaming, Boiling, by hot water.	Stewing and Braising.	Soup-making, Beef-tea.
Frying, wet, by hot oil.		
Frying, dry, by hot oil and conduction.		

Roasting is cooking by the radiant heat of a fire, which for this purpose must be burning brightly, with little or no smoke, and a large glowing surface. The meat is exposed to the heat within a few inches for from 5 to 10 minutes, with the result that the surface albumen is coagulated to about the thickness of a sixpence or so. If the meat be basted with dripping previously heated before the fire, this coagulation of the surface will be all the more rapid, since the boiling-point of oil is much higher than that of water. After this has been effected the meat is removed to a greater distance—and it may be as well to remember that double the distance means not half the heat but only a quarter,—and the process is continued very slowly at a greatly reduced temperature, the meat being really stewed in its own juices. If the subsequent heat be too great the surface skin cracks, allowing these juices to escape, and to prevent this the meat is basted with hot oil, which not only prevents cracking and even charring of the surface, but imparts brownness of colour and delicacy of flavour owing to the development of odorous appetizing substances. Roasting thus combines cooking by radiant heat with the advantages of the oil-bath, as in continental frying. Although the surface heat is very great, much above 100° C., the boiling-point of water, the heat in the interior of the joint may not be much above the coagulating point of albumen, 73° C., and any rise above that is to be deprecated, since continued heat renders albuminous matters hard and horny. The ordinary time given for roasting is $\frac{1}{4}$ hour per pound weight for beef, mutton, and

goose, rather more for pork and veal, and much less for poultry. Owing to expulsion of water the meat loses from 20 to 35 per cent of its weight.

Broiling or Grilling, as well as *Brandering*, is really roasting on a small scale *over* instead of in front of a radiant surface. The object aimed at is the same, the formation of a surface skin of coagulated albumen, and the retention within this of all the juices of the meat. To avoid breaking this coagulated layer, steak-tongs should be used instead of forks in turning the meat, while a fluted grill is advisable to retain fat, unless the meat is cooked by brandering in a double-hinged grill. Broiling is admirably suited for quickly roasting small articles, such as steaks, chops, bits of fowl, kidneys, fish, and the like, and besides the radiant heat of the fire, the hot vapours rising from it, consisting of steam and carbonic acid gas, assist in the process. According to Sir Henry Thompson the sauce "par excellence" for broiled meats is mushroom ketchup, and the garnish, cool lettuce, water-cress, or endive.

In the gas-cookers, so much used in towns, the processes of roasting and broiling are slightly modified, and with superior results. The oven, best whitewashed with lime, both for cleanliness and economy of heat, and jacketed with felt or other non-conductor, is heated from within by gas jets on the Bunsen principle, thus securing a smokeless flame, so that meat roasted or baked in it is really subjected, as in grilling, to a bath of hot gases arising from the combustion as well as to the heat radiated from the walls of the oven. In the gas-grill the radiant surface is usually a cast-iron grating which throws the heat down, the article to be cooked being placed below. If a kettle of water be placed above, not only will the waste heat be utilized, but the amount reflected is increased. Since the meat is placed below the grill in its own dripping-pan, it is subjected to a bath of oil vapour as well as to the radiant heat. Owing to the better control of the heat, steaks, &c., cooked by gas are generally superior to those done over or before the fire.

In *Baking*, as in roasting, the agent is radiant heat, but under the old system of baking in a close oven the result was very different, the meat being richer and therefore more indigestible, while it had a decidedly different flavour. This was owing to the circumstance that the operation was conducted at far too high a temperature after the preliminary "case-hardening", and the oil-laden vapours coming from the dish were caught on the sides of the oven and partially burned,

giving rise to an overpowering empyreumatic or "cooking" smell. Baking was thus practically roasting in a confined air-space; but in the modern oven, brick-lined or lime-washed as in Devonshire, and heated by gas jets, there is no difference between the flavour of a roasted joint and a baked one. To prevent the formation of half-burned oil owing to spluttering gravy, all that is wanted is to put the baking-pan containing the joint into a larger one containing a little water; this not only arrests particles of oil which would otherwise land on the sides and floor of the oven, but it serves as a water-jacket to regulate the heat and keep it down to about the boiling-point of water. When meat is placed in a pie-dish, it should be supported on something, such as an earthenware tray, in order to keep it from being scorched, and also from becoming sodden by excess of fluid. The loss of weight by baking and by boiling is much the same, about 25 per cent. Count Rumford has put it upon record that oven roasting is better than open roasting, but he adds that he despairs of getting the English mind to believe this, and Mr. Williams supports both his views and his conclusions. The predilection for open roasting is due to insular prejudice in the first place, and in the second to unsatisfactory ovens and other appliances, coupled with carelessness in their use.

Boiling of meat, like roasting and baking, aims at coagulating a surface layer of albumen, and thus cooking the meat in a vessel of its own skin, the heat being supplied in this case by hot water. Albumen is partly soluble in water, and to prevent loss of substance in this way the water must be boiling before the meat is put in; and the boiling-point will be all the higher if a little salt is added to the water. After the meat has been "case-hardened", the temperature should be lowered so as to keep the water not even simmering but just about 75° C. or so. As generally practised, the heat used during boiling is excessive, leading not only to waste of fuel, but progressively hardening the meat from without inwards. A fair idea of the temperature required will be obtained by adding after the first five minutes three pints of cold water to every gallon, and repeating every time the liquid boils in to that extent. It is quite true that if boiling be carried to excess the meat is boiled to rags, but this simply means that the connective tissue between the muscle fibre has become gelatinized, the fibres themselves are quite hard and indigestible, and may be recognized unchanged in the fæces.

Since under ordinary circumstances water boils at 100° C., the case-hardening heat produced by boiling is greatly inferior to that in an oven, and so, in spite of all precautions, some of the meat juices will escape into the liquid before coagulation has been effected. The boiling-point may be raised by adding salt to the water, as is generally done; but if a much higher point is desired, that can only be obtained by the use of a Papin's digester, practically a high-pressure boiler. As increase of pressure raises the boiling-point, so diminution of pressure lowers it, and in this way water at the tops of mountains may boil at a temperature which will not cook an egg, much less a potato. In sugar-refining, advantage is taken of this property to secure the evaporation of sugar solutions and the formation of sugar-crystals at a low temperature, thus avoiding the formation of uncrystallizable sugar.

In boiling, as in roasting, while the exterior is needlessly subjected to a temperature of 100° C. or over, the interior as tested by a thermometer rarely shows more than 80°, and for the best flavour and digestibility the meat should not be much over 73 or 75° C., since all that is wanted is the complete coagulation of the albuminous matters. This will be better obtained by cooking a longer time at a lower temperature after the first sharp heat, and thus where gas-cookers are used the saving of fuel alone is considerable. In order to prevent careless cooking from overheating, several appliances have been devised, more or less based on the principle of the familiar glue-pot, viz. a water-jacket. A *Bain-marie* consists of two tin vessels, an outer larger one containing water, and an inner one with the article to be cooked, so that the latter is heated by the water in the outer chamber. For travelling purposes, when space is at a premium and impedimenta of all kinds at a discount, this arrangement has often a top compartment, in which the steam from the outer jacket is utilized to cook vegetables or fish.

As applied to vegetables, boiling attempts to soften cellulose, rendering it tender and digestible as far as it may be so, to burst the envelopes of starch grains and convert some of the starch into dextrin. Vegetable proteids are often in the form of legumin, not coagulated by heat, and in their case excessive heat, though a waste of fuel, does no great harm to the dish. All vegetables, however, even rice, contain salts and other soluble matters for which they are valued, and for the sake of which indeed green vegetables are taken at all, and to boil

vegetables of this class would be to throw away the most useful part of their substance. Unless the water in which they are boiled is to be used as stock for soup, all such articles are best cooked by *Steaming*, and this process has the further advantage of preserving the shape of the dish, vegetable or fish, thus admitting of its being sent up to the table in a more tempting guise. The heating agent here is vapour, and if the process be carried on in a closed vessel, vapour at high pressure and therefore more penetrating. Steaming is specially suited for rice, which has so few salts that it cannot afford to lose any, and for potatoes, which, apart from their starch, are valued for their potash compounds. To retain these, potatoes are boiled "in their jackets", since potatoes contain no albumen to coagulate; steaming them not only saves loss of salts, but by bursting the starch grains more rapidly produces a fine "mealy" consistence. Occasionally the article to be cooked may contain deleterious or otherwise undesirable substances; thus some of the salt in salted fish, such as ling, or the irritating greenish sap of new potatoes. In these cases the article should be soaked in moderately tepid water to extract these matters as fully as possible, and then transferred to fresh water and boiled *de novo*.

Frying, properly understood, is boiling in oil, but as practised in this country is a dirty and wasteful combination of broiling, toasting, and basting. In *dry* frying, which is suitable for oily foods like herring, sausages, &c., a shallow frying-pan is used, and the food is either cooked in its own fat or with the aid of sufficient fat to prevent burning. Lard is about the worst form of fat for the purpose, since it is with great difficulty separated from substances fried in it, and imparts a disagreeable greasy taste and smell. As the temperature rises, the fat begins to sputter, a sign that water is being expelled; at a higher temperature the fat itself begins to boil quietly, and this is the correct stage for cooking; above this it smokes and is decomposed, forming various empyreumatic matters offensive alike to smell and taste. These stages in the cooking of oil succeed each other with great rapidity when there is but a thin layer of fat, as in dry frying, and hence this process is not only the most wasteful, but the most offensive of all, and fried articles are apt to be spoiled by impregnation with excess of fat, or by scorching and the presence of irritating products of fat decomposition.

Wet frying, or *sautéing*, is properly boiling in oil, and demands

a deep sauté-pan, best fitted with a grating or frying basket. Into this is put as much oil as will cover the article, say fish, that is to be fried, and the oil is heated till it browns a bit of bread held in it for a second or two. The fish is now put into the hot oil and allowed to brown, and when the surface albumen is thoroughly coagulated the pan is drawn aside, as in boiling with water, and the process finished at a lower temperature. The fish may now be lifted out by the tray and the oil drained off, which it will do all the more readily owing to its great fluidity when heated; the oil may be used again and again unless it has been smoking, a sign of overheating and consequent decomposition. Fish are often prepared for frying by being coated with egg and afterwards dipped in bread-crumbs. Owing to the fact that boiling oil is about half as hot again as boiling water, the egg albumen coagulates instantly, thus forming a protective skin, while the bread-crumbs are turned into dextrin or even caramelized. If the latter are coarse or thickly spread they absorb some of the oil, a thing to be avoided. The best medium for this purpose is ordinary olive-oil of second quality, good kitchen dripping does about as well, and lard worst of all.

Stewing occupies a position similar to that of roasting on the one hand, and soup-making on the other. As in the latter process, the object is to make an extract of all the nutritive juices of the food, which are then used to cook the article; it is thus cooking by means of heated juices previously extracted from the food itself. A low steady heat is wanted for this purpose, and gas-cookers supply this to perfection. The meat is freed from bones, cut into pieces of a convenient size and seasoned, then the bones are broken up and laid in the pot with the meat above them with salt, and the whole covered with *cold* water, covered closely, and placed near the fire so as to maintain a steady low temperature, about three-fourths of that of boiling water. If vegetables are added, as in Irish stew, they are best put in later on, finely chopped, and accompanied by bay leaves, sage, cloves, or other aromatics, the odour of which would be dissipated on continued heating. The slower the stew the better is it done; tough meats may be rendered more digestible by the addition of a little vinegar to loosen their fibres and convert them into acid albumens. Since nothing is lost in this process, it is the most economical of any, and after the preliminary chopping of meat and vegetables needs no attention for hours if the heat is sufficiently low.

In *Braising*, the meat is covered with an extract of animal and vegetable juices, instead of water, and thus becomes impregnated with their flavour. This method of stewing is thus specially adapted to foods somewhat insipid in themselves, like white flesh and poultry, and the addition to these of a few pieces of ham, bacon, or sausage, together with vegetables, is really a method of imparting sapidity by means of a sauce prepared at the same time and in the same dish as the food itself. Very often at the end of the process the meat is browned slightly by a top heat, still keeping the dish closed; this demands a concave lid into which red-hot cinders may be put, or it may be done by radiation before the fire or from a gas ring. A recipe for ordinary braising is given, quoted by Sir Henry Thompson from Gouffe's *Livre de Cuisine.*

Bœuf à la mode. Take about 4 lbs. of thick beef-steak cut square. Take nearly $\frac{3}{4}$ lb. of fat bacon, cut off the rind, which should be put aside to blanch, *i.e.* plunged into boiling water for a minute or two to remove acrid matters, then cut the bacon in strips for larding, about $\frac{1}{3}$ in. square, and sprinkle them with pepper. Lard the meat and tie it up, then place it in a stew-pan with rather less than a pint of white wine, a wine-glass of brandy, a pint of stock, a pint of water, 2 calves' feet already boned and blanched, and the rind of bacon also blanched. Put it on the fire, adding a little less than 1 oz. of salt. Make it boil and skim, next add fully 1 lb. of carrots, 1 onion, 3 cloves, 1 bunch of herbs, and 2 pinches of pepper. Place the stew-pan on the corner of the stove, cover, and allow to simmer very gently for $4\frac{1}{2}$ hours. Try the meat with a skewer to ascertain when it is sufficiently cooked; then put it in a dish with the carrots and the calves' feet, and keep these covered up hot till serving. Next strain the gravy through a fine sieve, remove carefully every atom of grease, and reduce it one-quarter over the fire. Lastly, untie the beef, place it on the dish for serving, add the calves' feet, each cut in 8 pieces, the carrots cut into pieces the size of a cork, and 10 onions glazed. Arrange the calves' feet, carrots, and onions around the beef, pour the sauce over the meat, keeping any surplus till next day. Taste, in order to ascertain if sufficiently seasoned; sometimes a clove of garlic is added.

Soup-making, like stewing, proceeds upon the principle of extracting as much as possible from the materials, leaving it an open question whether that exhausted material is to be used or not. Extraction by water is seen in its simplest form in the

making of beef-tea already described, and this is really a type of the process. Meat must be cut up into suitable pieces in order to present a large surface to the extracting liquid, while to increase its solvent power a little vinegar as well as salt is added for tough meat and vegetables, or even a very little hydrochloric acid. In no case must the heat reach the coagulation-point of albumen, 73° C., so that vegetables which require higher temperatures to soften them must be cooked separately, preferably by steam, and added to the soup at the proper time, or the common practice may be followed of putting on the vegetables first at a high temperature, then cooling, and adding the meat. Last of all are the flavourings, herbs and others, which would have much of their odourous substances dissipated by overheating if added sooner.

The simplest and weakest soup is the product of the *Stock-pot.* This useful article receives all meat and vegetable trimmings and scraps which have been withdrawn from previous dishes, all water in which meat or vegetables have been boiled, everything, in short, which contains nutriment in either the solid or the liquid form. It stands continually on the hob, thus gradually concentrating its contents, and producing a true meat or vegetable soup called *Stock*, which may be used instead of water, say for boiling fowls, thus giving a higher boiling-point than water, and at the same time preserving the nutriment which always escapes from meat in boiling.

On the same lines, but more elaborate in detail, is the French peasant's *Pot-au-feu.* This is really a good Scotch broth of meat and vegetables, but made with stock instead of water, and, as in the home product, the boiled beef is intended to be eaten immediately after the soup. Since the pot-au-feu is the basis of nearly all soups—and there are over 500 known to French cooks,—Gouffe's description of the materials and *modus operandi* will be useful. For the small pot-au-feu, furnishing broth for 4 or 5 persons, there are required nearly 2 lbs. meat, including 5 ozs. of bone, 7 pints water, 1 oz. salt, 5½ ozs. carrots and the same of onions and turnips, 7 ozs. leeks, nearly ½ oz. celery, 1 clove stuck in an onion, and nearly 1 oz. parsnip. Some add a little garlic, but its flavour tends to destroy the aroma of the broth, and further renders it unsuitable for the use of invalids. For the large pot-au-feu double the quantities of meat and vegetables, but use only 10½ pints of water. The portions of beef adapted for the pot-au-feu are the thick portion of the leg and shoulder; the lower parts, from the knee down,

are inferior, consisting chiefly of bone, skin, and tendon. On the whole, perhaps the leg is superior to the shoulder for this purpose, and all meat used should be as fresh as possible. In the first place, care must be taken to have a well-made fire which will last without much addition of coal, and supply a constant gentle heat. The cover of the pot should be left slightly open, as broth becomes cloudy in a closed vessel.

Now proceed as follows:—Separate the meat from the bones, tying up the former to keep its shape for serving, and chopping the bones into little bits. First put the bones in the pot and the meat upon them. Pour in the water cold and place the pot on the fire, add the salt and bring it to the boil, and as soon as the scum rises pour in a little cold water and skim with a perforated spoon. Let it boil three separate times, skimming each time, after which the broth should be sufficiently skimmed. Wipe carefully the edge of the pot, and add the vegetables, which will check the boiling for a few minutes; as soon as it begins again, place the pot on the corner of the fire, letting it simmer gently only, 5 hours for the large and 3 hours for the small pot-au-feu,—it is essential that the simmering be quite regular and continuous. When the broth is made, take out the meat and put it in a dish, taste the broth to see if it is salt enough; if more salt is wanted it should not be added till the broth is being served, and care should be taken not to salt the broth too highly at first, as it always becomes salter on being warmed up on the second day, and still more so when reduced to a sauce. Another essential point is to free the broth perfectly from grease, after the meat is taken out, the pot being still on the fire. The vegetables should be left in the pot only just long enough to cook them; by this time they have given their flavour to the broth, after which they only rob it of its goodness. It is generally considered, and justly so, that the broth should have a golden tint; the flavour is not improved thereby, but the eye is satisfied. Yet care should be taken not to alter the flavour, therefore if any colouring matter is to be used it should be caramel, while fried onion, fried carrot, and similar substances should be avoided for the reason given.

A stronger extract than the pot-au-feu is *Grand Bouillon*, in which to the meat and vegetables already used there are added bones, connective tissue, tendon, &c., for the sake of the gelatin extracted from them.

Consommé is the richest form of soup, and is made from beef, veal, and fowl, the last two roasted and sliced for the sake of

the flavour thus obtained, with vegetables as above, but Grand Bouillon instead of water.

The multitudinous soups of French cookery books have all been reduced by Sir Henry Thompson to five classes, as follows:—

1. A clear soup from ordinary beef, veal, sometimes mutton and pork in the form of ham or bacon, either in the weak or broth form, or as consommé.

2. A clear soup from fowl.

3. A clear soup from game.

4. A clear soup from fish proper and with shell-fish, including bisques, *i.e.* purées of cray-fish.

5. A clear soup from vegetables only, comprising herbs, roots, grains, and farinaceous substances.

A soup may be thickened by the addition of gelatinous matters, by farinaceous substances, or by animal and vegetable purées; thus, a meat consommé may be enriched by a purée of fowl, or of potatoes and herbs, &c. &c.

SUMMARY.

1. Cooking exercises both mechanical and chemical effect upon food.

2. All methods are reduced to two classes, depending on whether the meat juices are to be retained or extracted.

3. In roasting and other methods of the first class, the juices are retained by preliminary case-hardening by intense heat, after which cooking proceeds at a lower temperature, rising in the interior to the coagulating point of albumen.

4. Stewing first extracts the juice and then cooks the meat in it, and is thus conducted slowly and over a long time.

5. Soup-making aims at extracting as much as possible, and therefore begins in the cold, never rising above 73° C.

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